

EFFECT OF SENSORY-MOTOR INTEGRATION TRAINING ON BALANCE AND FUNCTIONAL MOBILITY IN CHILDREN WITH AUTISM SPECTRUM DISORDER

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Keywords

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Abstract

Purpose: Those with ASD suffer from difficulties with balance, postural control, coordination, and functional mobility. The use of sensory-motor integration in addition to traditional physical therapy may provide additional benefit. The purpose of this research is to find out the effect of the combination of sensory-motor integration with traditional physical therapy on the balance and functional mobility of those with ASD.

Methods: Randomized controlled trial study was carried out on 60 children with ASD at Step Ahead Autism Centre, Lahore. Participants were equally divided into two groups through the process of sealed envelope method. Group 1 was exposed to sensory-motor integration along with traditional physiotherapy, while Group 2 was exposed only to traditional physiotherapy. The sessions were 25 to 30 minutes long, performed four times a week for four months. Balance was measured through the Berg Balance Scale (BBS), while functional mobility was measured by performing TUG test both pre and post-intervention.

Results: There were also observed statistically significant within-group improvements in terms of BBS and TUG ($p < .001$). Specifically, in Group 1, the BBS increased from 34.77 ± 2.70 to 41.77 ± 2.87 , and TUG reduced from 14.64 ± 1.43 to 10.95 ± 1.69 seconds. In turn, in Group 2, BBS increased from 36.06 ± 3.19 to 40.36 ± 3.24 , and TUG decreased from 15.28 ± 1.58 to 13.38 ± 1.80 seconds.

Conclusion: Improvement was seen in both treatment groups concerning balance and functional mobility. More significant numerical changes were noted in the treatment group where sensory-motor integration training was done alongside the traditional physical therapy sessions. This indicates that sensory-motor integration training can add more value to the lives of children with ASD.

INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that involves impairments in social communication and

interaction as well as restricted or repetitive patterns of behavior, interests or activities (Gardinal et al., 2026). Despite the fact that the features characterizing ASD diagnosis

have mostly to do with social communication and restricted or repetitive behaviors, many children diagnosed with ASD also show impairments in motor function, coordination, balance, and movement (González León & González-Olguín, 2024). Motor impairments in children with ASD can negatively impact their participation in activities of daily living and have an effect on independence and quality of life. Motor impairments in children with ASD may involve issues with motor planning, postural control, bilateral coordination, walking, and balance. Problems with the maintenance of postural control are bound to negatively impact participation in physical activities and add to the difficulties associated with functional activities (Miller et al., 2023). Balance control is especially significant because it involves integration of different senses in order to elicit proper postural reactions (Podsiadlo & Richardson, 1991). Sensory-motor integration involves organizing sensory information in order to facilitate appropriate and goal-directed motor responses (Narzisi et al., 2022). Sensory-motor interventions can include vestibular stimulation, proprioceptive activities, tactile input, balance activities, coordination activities, and functional movement activities. Sensory-motor interventions could be especially pertinent to children with ASD given that sensory processing issues can impact motor planning and posture (Su et al., 2025).

In prior research, issues with balance and postural control have been identified in children with ASD (Qu et al., 2025). According to a systematic review and meta-analysis problems with several different measures of balance control have been found in children and adolescents with ASD, including sensory orientation, verticality, and anticipatory postural adjustments (Xu et al., 2025). From these results, it seems that balance deficits in ASD are multifactorial in nature (Siqueiros et al., 2025).

Intervention studies have also demonstrated that interventions that include exercise and motor activities can be helpful in improving postural stability and motor skills in children with ASD. Demonstrated an improvement in postural control after receiving psychomotor rehabilitation

therapy (Ben Hassen et al., 2023). Similarly observed an improvement in the balance function and executive function of children after sensory integration training (Deng et al., 2023). Furthermore, also observed positive effects of postural rehabilitation in children with ASD in terms of postural control (Caldani et al., 2020). A meta-analysis and found positive effects of exercise interventions that target balance in children with ASD (Djordjević et al., 2022).

Recent literature provides more evidence regarding structured sensory motor interventions. Observed that structured sensory motor exercise program improves postural stability in autistic children (Aly et al., 2026). Several systematic reviews have also provided evidence of the effectiveness of sensory processing and sensory integration interventions for autism despite different methodologies employed in studies (Camino-Alarcón et al., 2024). A conclusion that several interventions have the capacity to improve the postural balance of individuals with ASD (Date et al., 2024).

However, a need still exists for conducting comparative clinical trials between sensory-motor integration training supplemented with conventional physical therapy versus conventional physical therapy alone. Such a comparative study is needed since conventional physical therapy could improve strength, movement, balance, flexibility, and functional performance of participants by itself. An active comparison group makes it possible to analyze the added value of the sensory-motor integration training.

The current randomized controlled trial was aimed at the evaluation of the influence of supplementary sensory-motor integration training on balance and functional mobility of children with ASD compared with conventional physical therapy alone. The main outcome measures were balance assessed via the Berg Balance Scale (BBS) and functional mobility measured using the Timed Up and Go (TUG) test.

Methods

Study Design: This research utilized a randomized control trial method in comparing the effect of sensory motor integration therapy coupled with regular physical therapy versus regular physical therapy alone. This study was done at Step Ahead Autism Center, Lahore, Pakistan.

Participants: In total, 60 children who were suffering from ASD took part in this study. The participants were divided evenly into two groups, with 30 participants per group. Group 1 underwent sensory-motor integration exercises along with regular physical therapy, while Group 2 underwent only physical therapy (Hariri et al., 2022). The real data set consisted of participants who were 7–12 years old.

Eligibility Criteria: The participants in the study were children diagnosed with ASD, who could comprehend simple instructions given verbally and were capable of participating in structured physical activities. The eligibility criteria for the study included only those children who did not have any other neurological condition besides autism, severe musculoskeletal abnormalities or disabilities, significant cognitive deficits, recent surgery or injuries, or any uncontrolled medical conditions that affect physical activities.

Sample Size and Allocation: Sample Size Estimation was conducted through G Power software, assuming effect size of 0.50, significance level of .10, power of study of .60 and allocation ratio of 1:1. Subjects were enrolled from the clinical setting and then allocated into the two intervention groups by way of sealing envelopes.

Intervention:

Group	Intervention	Activity Components	Session Duration	Frequency	Total Duration	Purpose
Group A	Sensory Integration Training + Conventional Physical Therapy (CPT)	Vestibular training, proprioceptive training, tactile stimulation, coordination exercises, along with conventional PT exercises such as stretching, strengthening, and range of motion (ROM) exercises	25–30 minutes	4 sessions/week	4 months	To improve sensory processing, balance, postural control, motor coordination, and functional mobility
Group B	Conventional Physical Therapy (CPT) only	Conventional PT exercises such as stretching, strengthening, and range of motion (ROM) exercises	25–30 minutes	4 sessions/week	4 months	To improve general strength, mobility, coordination, balance, and functional performance

Outcome Measures

Berg Balance Scale: The balance test was done using the Berg Balance Scale (BBS). This scale is made up of 14 functional tests that evaluate the different features of static and dynamic balance. Each of these tests can be scored on a scale of 0 to 4, giving a total score of 56. The BBS test was conducted both pre and post four month intervention period.

Timed Up and Go Test: Mobility was tested through Timed Up and Go (TUG) Test. In this test, the patient rises from the chair, walks for about 3 meters, and then turns to walk back to the chair. This is done while the time taken to do so is measured in seconds. The shorter the time, the better the functional mobility. This test was conducted at baseline and after the intervention.

Data Collection Procedure: The baseline demographic data of the subjects was determined before the administration of the intervention. Subjects were tested using the BBS and TUG before conducting the intervention. Upon completing the four-month intervention, all subjects underwent testing once again using the aforementioned tests. The signed informed consent was done by the parent or guardian of the subjects. The identities of the subjects were kept anonymous.

Statistical Analysis: Data analysis was performed using Statistical Package for the Social Sciences (SPSS), Version 26, as stated in the study protocol. Descriptive statistics were utilized to describe the characteristics and measures obtained from participants. Mean and standard deviation were used in the summary of continuous variables. Normality of the sample distribution was analyzed using the Shapiro-Wilk test. Within-group pre- and post-intervention changes were evaluated through appropriate paired comparisons. Change scores were computed for between-group comparisons. According to the study protocol, p-value < .10 was considered as the significance level. For the current manuscript, the results were compared with the raw data in the SPSS dataset. Values of $p = .087$ and $p = .105$, which were stated in the thesis for the BBS and TUG change, respectively, could not be verified by the raw data. Statistically significant between-group difference in change was demonstrated for both outcomes using $p\text{-value} < .001$. Thus, results obtained from the raw data were reported in the current manuscript in contrast to the thesis.

Results

Participant Characteristics: There were 60 ASD children who participated in the research, with 30 participants assigned to each group. The average age of the children in Group 1 was 10.03 ± 1.97 years, while the average age in Group 2 was 9.67 ± 1.79 years. Age difference between groups was not statistically significant ($p = .454$).

Table 1 Demographic Characteristics of Participants

Demographic characteristic	Group 1: SIT + CPT (n=30)	Group 2: CPT (n=30)	Between-group p-value
Age (years), Mean $\pm$ SD	10.03 $\pm$ 1.97	9.67 $\pm$ 1.79	0.454
Age range (years)	7-12	7-12	—

Since there was no statistical significance of age among the groups, it can be said that the average age was similar for both the groups.

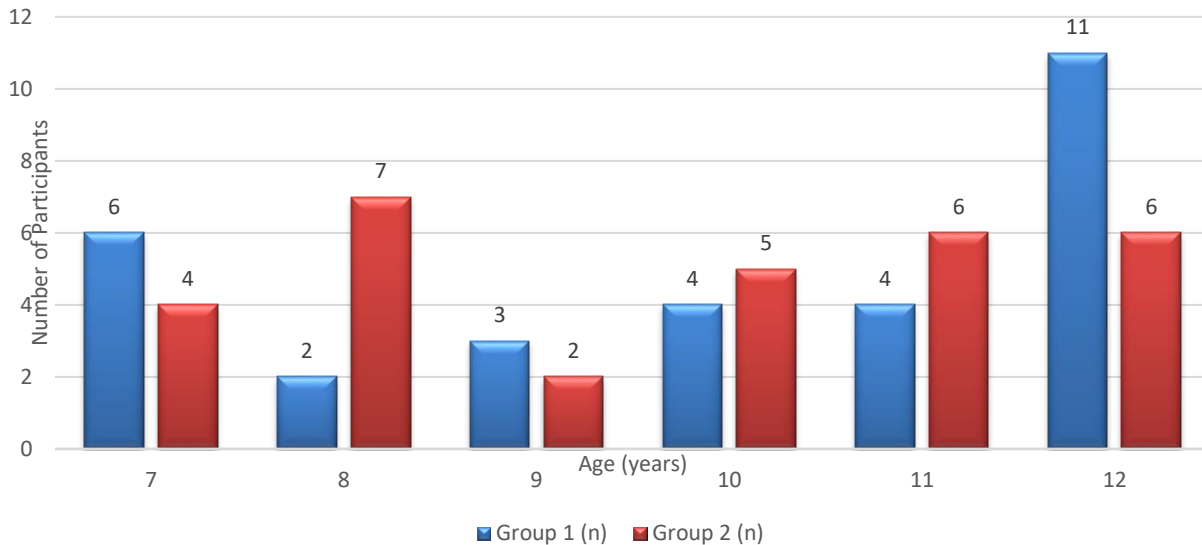


Figure 1 Age Distribution By treatment Group

Normality Analysis: The Shapiro-Wilk test results showed that the major pre- and post-intervention outcomes had nearly normal distribution in both groups. For Group 1, the Shapiro-Wilk test results were as follows: pre-intervention BBS, $W = .971$, $p = .564$; post-intervention BBS, $W = .960$, $p = .303$; pre-intervention TUG, $W = .988$, $p = .979$; and post-intervention TUG, $W = .952$, $p = .194$. For Group 2, the results were as follows: pre-intervention BBS, $W = .971$, $p = .556$; post-intervention BBS, $W = .976$, $p = .701$; pre-intervention TUG, $W = .954$, $p = .220$; and post-intervention TUG, $W = .981$, $p = .850$.

Balance Outcomes: For Group 1, there was a notable improvement in their BBS scores after the intervention program. The mean BBS score for this group increased from 34.77 ± 2.70 before the intervention to 41.77 ± 2.87 after the intervention, which is an approximate 7.00 point improvement. This within-group difference was statistically significant ($p < .001$). For Group 2, there was also a notable improvement in their BBS scores after the intervention program. The mean BBS score for this group increased from 36.06 ± 3.19 before the intervention to 40.36 ± 3.24 after the intervention, which is an approximate 4.30 point improvement ($p < .001$). Therefore, both treatments resulted in enhanced balance, but the difference in numbers is larger for Group 1.

Table 2 Within-Group Comparison of Pre- and Post-Intervention Scores in Group 1

Outcome Measure	Pre-intervention Mean $\pm$ SD	Post-intervention Mean $\pm$ SD	Mean Difference	t-value	p-value
BBS	34.77 ± 2.70	41.77 ± 2.87	7.00	40.262	<0.001

TUG (seconds)	14.64 ± 1.43	10.95 ± 1.69	-3.69	-23.766	<0.001
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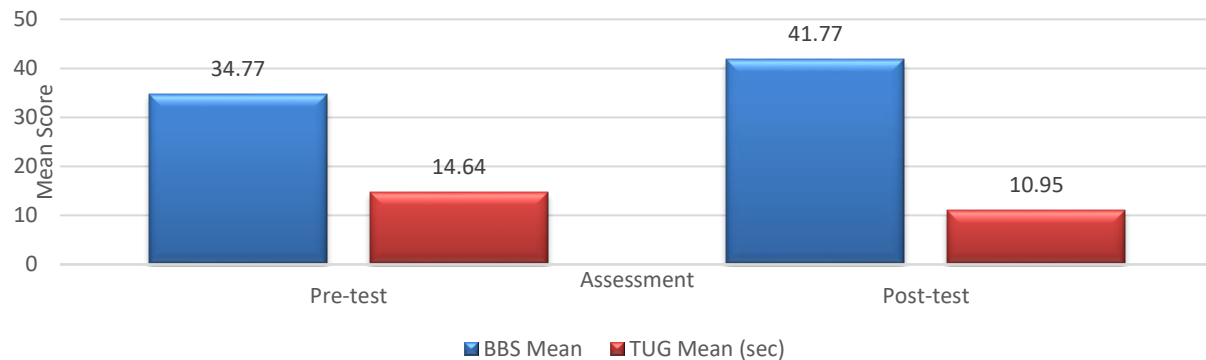


Figure 2 Within-Group Comparison of Pre- and Post-Intervention Scores in Group 1

Functional Mobility Outcomes: Improvement in functional mobility was observed in both the groups. In group 1, the mean TUG completion time was reduced from 14.64 ± 1.43 seconds prior to intervention to 10.95 ± 1.69 seconds post intervention, which shows a reduction of about 3.69 seconds. The difference was statistically

significant ($p < .001$). In group 2, the mean TUG completion time was reduced from 15.28 ± 1.58 seconds to 13.38 ± 1.80 seconds, showing a reduction of about 1.91 seconds. The difference was statistically significant ($p < .001$). The reduction in TUG completion time was numerically larger in group 1 compared to group 2.

Table 3 Within-Group Comparison of Pre- and Post-Intervention Scores in Group 2

Outcome Measure	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Difference	t-value	p-value
BBS	36.06 ± 3.19	40.36 ± 3.24	4.30	30.094	<0.001
TUG (seconds)	15.28 ± 1.58	13.38 ± 1.80	-1.91	-16.869	<0.001

Between-Group Comparison: This data set of SPSS was employed to confirm the differences between groups in changes of scores. BBS score change in Group 1 was approximately 7.00 points whereas in Group 2 - 4.30 points. The between-group difference in BBS score change was

statistically significant ($p < .001$). TUG score change in Group 1 was approximately 3.69 seconds while in Group 2 - 1.91 seconds. The between-group difference in TUG score change was statistically significant too ($p < .001$). Hence, the confirmed data set demonstrates that Group 1

had significantly more progress in balance and functional mobility than Group 2.

Table 4 Between-Group Comparison of BBS Scores

BBS Measure	Group 1: SIT + CPT Mean $\pm$ SD	Group 2: CPT Mean $\pm$ SD	t-value	p-value
Pre-intervention	34.77 $\pm$ 2.70	36.06 $\pm$ 3.19	-1.686	0.097
Post-intervention	41.77 $\pm$ 2.87	40.36 $\pm$ 3.24	1.777	0.081
Change score	7.00 $\pm$ 0.95	4.30 $\pm$ 0.78	11.958	<0.001

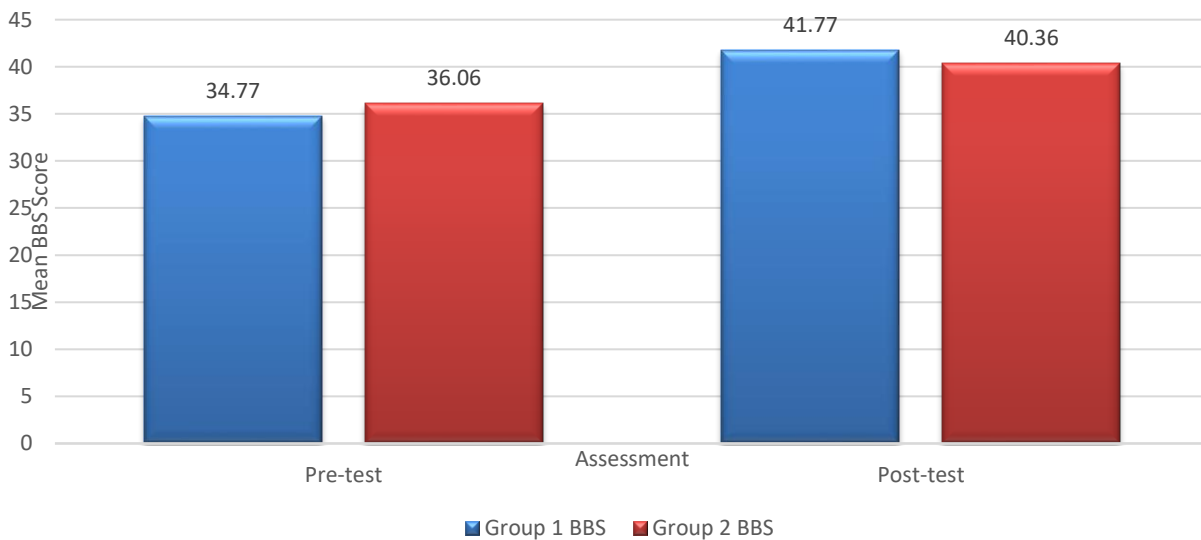


Figure 3 Between-Group Comparison of BBS Scores

Table 5 Between-Group Comparison of TUG Scores

TUG Measure	Group 1: SIT + CPT Mean $\pm$ SD	Group 2: CPT Mean $\pm$ SD	t-value	p-value
Pre-intervention	14.64 $\pm$ 1.43	15.28 $\pm$ 1.58	-1.656	0.103
Post-intervention	10.95 $\pm$ 1.69	13.38 $\pm$ 1.80	-5.367	<0.001

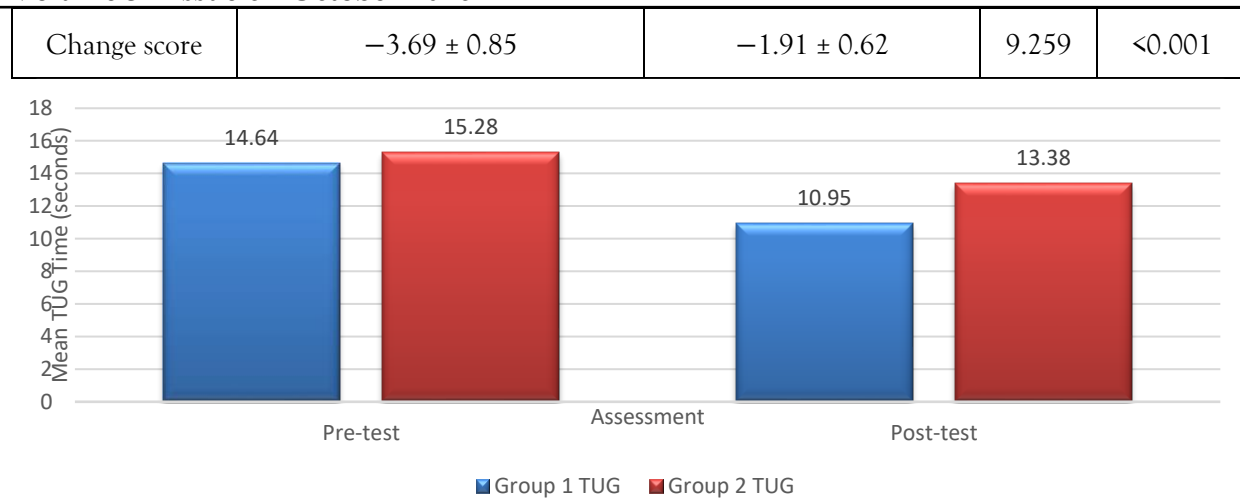


Figure 4 Between-Group Comparison of TUG Scores

Discussion

The objective of this randomized control trial was to test whether the addition of sensory motor integration therapy along with conventional physical therapy was effective in improving the balance and functional mobility in children with autism spectrum disorder as compared to conventional physical therapy only. The main outcome of this study was that both treatment groups showed significant improvements in balance and functional mobility after a four-month intervention period. But the group receiving sensory motor integration therapy along with conventional physical therapy had improved balance and functional mobility by a greater extent. More importantly, the verification of this study using the underlying SPSS data set indicated that there was statistical significance in the change in the scores of BBS and TUG between two groups of participants. The improvement in BBS was very impressive in this case. Participants who received sensory motor integration therapy showed an improvement in the mean BBS score from 34.77 to 41.77, whereas those receiving conventional physical therapy improved from 36.06 to 40.36. The mean improvement was approximately 7.00 points in Group 1 compared with 4.30 points in Group 2.

This is aligned with existing literature indicating that balance and postural control are motor

domains of impairment in children with ASD. For instance, Xu et al. (2025) noted that there were impairments in sensory orientation, verticality, and anticipatory postural adjustments in children and adolescents with ASD. Balance control is multidimensional; hence, it calls for interventions that consider factors beyond muscle strength and range of motion alone. The greater improvements in Group 1 could have been facilitated by the multidimensional approach used in the sensory-motor intervention. Vestibular, proprioceptive, tactile, coordination, balance, and functional activities were part of the sensory-motor intervention. The activities entail processing of sensory information and motor responses; hence, the participants have chances of improving their postural reactions, coordination, body awareness, and balance through repeated practice. The results are in line with those of Deng et al. (2023) that indicated improvement in balance in ASD children after sensory integration training. The results suggested that sensory integration interventions have an impact on the processing of visual, vestibular, and proprioceptive information for postural control.

Improvements in postural control following psychomotor rehabilitation were also found by Ben Hassan et al. (2023) in children with ASD. Despite the fact that the intervention methods and outcome measures used by the authors are

different from the ones employed in the current study, the results add even more credibility to structured intervention methods in terms of postural performance. Moreover, the outcomes of the present study are similar to the findings of the meta-analysis conducted by Djordjević et al. (2022) and demonstrating positive impact of exercise interventions intended at improving the balance in children with ASD. In general, the research evidence demonstrates that the use of structured motor intervention is quite effective in the case of children with ASD. The improvements in TUG performance were found in both groups of participants as well. Group 1 improved their performance from 14.64 seconds to 10.95 seconds, while Group 2 was able to improve their performance from 15.28 seconds to 13.38 seconds. The bigger decrease in TUG time in Group 1 shows a bigger numerical improvement in functional mobility after the inclusion of sensory-motor integration training.

The improved results in the conventional physical therapy group are also clinically meaningful. Conventional physical therapy comprised stretching, strengthening, range-of-motion, balance training, and functional movement. Such interventions might enhance physical skills needed for functional movement, such as strength of the lower limbs, efficient movement, flexibility, balance, and transitional movements. Additional gains in Group 1 might be attributed to the role played by sensory-motor activities in the dynamic functional performance of participants. In order to perform a test of TUG, one has to integrate several motor skills, namely to rise from a chair, start walking, turn, maintain dynamic balance, and sit down. These skills might be gained through sensory-motor activities as they enable repeated coordination of sensory data with movement. The results of the research coincide with the results of Su et al. (2025). They indicated that intervention with whole-body movements could result in improved gross motor performance in children with ASD. These findings confirm the general idea that active interventions could lead to motor gains. This work extends this idea, demonstrating

gains after both conventional physical therapy and sensory-motor and physical therapy interventions. Furthermore, the current research findings align with those from systematic reviews that focus on the importance of sensory-processing and sensory-motor interventions. According to Camino-Alarcón et al. (2024), there is evidence that supports sensory-processing and sensory integration, while according to Date et al. (2024), there are various types of interventions linked to improved postural balance in people with ASD. The major strength of the current research is that an active control group is used. Since both groups undergo conventional physical therapy at the same frequency and over the same period of time, the difference can be analyzed in regard to the sensory-motor integration component only. Such comparison is more informative than comparing sensory-motor intervention with no intervention at all. Another strength of the current research is that the intervention takes four months. In this way, the participants have more time to get used to the intervention procedures.

However, one must be cautious when interpreting the findings as evidence of the single cause of the observed improvements. ASD is highly variable; in addition to age and cognition, sensory integration and processing abilities, severity of ASD, motivation, and assistance can influence motor performance. The current research investigated the functional outcomes, but did not examine sensory processing, neurophysiological functioning, and postural stability. Consequently, it is impossible to specify the physiological cause of the observed differences based on the provided data. The interpretation of the statistical findings must also be cautious. There was inconsistency in the p-values for the between-groups difference in change scores in the original thesis: $p = .087$ for BBS and $p = .105$ for TUG in some sections, while another results section presented $p < .001$ for both outcomes. Checking the findings with the underlying SPSS dataset reveals that $p < .001$ for both differences between groups in change scores. The current paper utilizes the p-values that are backed by the underlying dataset. Since the proven between-groups result is statistically significant at

$p < .001$, the statement about higher improvement in Group 1 does not depend on the unusually high $p < .10$ criterion initially set in the thesis. However, the initial approach to statistical analysis should remain unchanged in the description of the research.

Conclusion

The results of the current randomized controlled trial have revealed significantly improved balance and functional mobility in children with ASD who were administered either sensory-motor integration therapy in combination with traditional physical therapy treatment or only traditional physical therapy treatment. Children who received the combination of the two types of therapies have shown significantly better results in both BBS and TUG tests than children who have been provided with traditional physical therapy treatment only. The verified differences in change scores between the groups of children have turned out to be statistically significant for both BBS and TUG ($p < .001$). The obtained results indicate the possibility of using the technique of sensory-motor integration therapy as a complementary one in traditional physical therapy for children with ASD.

Limitations

1. Firstly, the number of children included in the sample was quite limited – only 60 children participated in the study, with half of them in each group. Such a small sample size makes it hard to generalize results to other children with autism.
2. Secondly, the experiment was carried out in one clinical center in Lahore. Different clinical settings, different rehabilitative resources, different therapists and patients may lead to different results, thus making it difficult to generalize to other groups of people.
3. Thirdly, the experimental treatment period was four months, but there is no information about the follow-up period after the intervention.

Recommendations

1. The studies need to use a bigger sample size in future to increase the generalizability of the results.
2. The follow-up evaluations need to be considered in order to identify whether there is any sustained improvement in the balance and functional mobility after the completion of intervention.

Further research needs to consider using objective measurements of postural control and balance along with clinically assessed functional scales.

Funding

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Ethics Approval

The study was conducted according to the ethical guidelines of TIMES University, Multan, Pakistan, and was approved under **IRB No. TIMES/AD/2026/1133**. Written informed consent was obtained from parents/guardians, and participant information was kept confidential.

Author Contributions

Shahid Rasool: conceptualization, methodology, data collection, data analysis, interpretation of results, and manuscript preparation. Muhammad Hassan Sajjad: supervision and academic guidance. Hamna Maryam: minor contribution to the research and manuscript preparation. All authors reviewed and approved the final manuscript.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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