Original Article
http://mjiri.iums.ac.ir
Medical Journal of the Islamic Republic of Iran (MJIRI)

Med J Islam Repub Iran. 2026 (11 Jul);40.73. https://doi.org/10.47176/mjiri.40.73

Does Fine Motor Performance under Single and Dual Task Conditions Predict Participation in Children with Specific Learning Disabilities? A Cross-Sectional Study

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Received: 16 Feb 2026 Revised: 31 Jun 2026 Accepted: 9 Jul 2026 Published: 11 Jul 2026

Abstract

Background: Children with specific learning disabilities (SLD) often experience difficulties in activities of daily living that are essential for independence. Fine motor skills, particularly under dual-task conditions, are crucial for facilitating participation in these activities. This study compared fine motor performance under single and dual-task conditions between children with SLD and their typically developing peers, and examined the associations between task performance and participation in activities of daily living.

Methods: A total of 124 elementary students, including children with SLD and their typically developing peers (TDs), were recruited for this cross-sectional comparative study. Participants completed the Purdue Pegboard Test (PPT), and their participation in activities of daily living was assessed using the Jebsen-Taylor Hand Function Test (JTHFT). Independent t-tests, correlations, and regressions were conducted.

Results: In this study, 62 children with SLD and 62 typically developing peers participated, with a mean age of 9.41 years (SD=1.02). Children with SLD performed significantly worse in both single-task and dual-task conditions and showed lower participation compared to their typically developing peers ($P<0.05$). However, no significant associations were identified between task performance and participation ($P>0.05$).

Conclusion: The findings suggest that children with SLD exhibit deficits in fine motor performance, particularly under dual-task conditions, indicating increased sensitivity to cognitive load. Therefore, special attention should be given to training fine motor skills in both single and dual-task conditions for these children. Additionally, the factors affecting these children's participation require specific examination.

Keywords: Specific Learning Disorder, Dual-Task, Motor Skills, Participation

Cite this article as: Zamiran S, Hejazi-Shirmard M, Nobahar Ahari M, Nasiri A, Zayeri F. Does Fine Motor Performance under Single and Dual Task Conditions Predict Participation in Children with Specific Learning Disabilities? A Cross-Sectional Study. *Med J Islam Repub Iran.* 2026 (11 Jul);40:73. https://doi.org/10.47176/mjiri.40.73

Introduction

Specific Learning Disability (SLD) is a neurodevelopmental condition characterized by significant difficulties in acquiring and using academic skills, despite normal or above-average intelligence and adequate education (1, 2).

It is one of the most frequently diagnosed conditions in children, typically manifesting during the school years (1).

The primary subtypes of SLD include dyslexia, which is characterized by difficulties in reading accuracy, fluency,

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Key Messages:

↑What is "already known" in this topic:

Children with specific learning disabilities (SLD) exhibit impairments in postural, gross, and fine motor skills compared to their typically developing peers. Although research has primarily focused on their gross motor performance, fine motor skills—especially under dual-task conditions—are crucial predictors of participation and academic achievement; however, they have received relatively little attention.

→What this article adds:

Children with SLD demonstrated significantly poorer performance in dual-task conditions and exhibited lower levels of participation compared to their typically developing peers. However, no significant relationships were identified between task performance and participation, indicating that future research should investigate additional factors that may influence their participation in activities of daily living.

and comprehension; dysgraphia, which affects written expression, including spelling, handwriting, and composition; and dyscalculia, which impairs numerical reasoning, arithmetic skills, and mathematical problem-solving (1).

Poor motor skills are frequently observed in children with SLD (1, 2). Studies have identified manual dexterity, bilateral coordination, and balance as common motor deficits in these children (3). These impairments in fine and gross motor skills can adversely affect their ability to perform various tasks and limit their participation in physical activities with peers, such as running, jumping, holding a pencil, writing, and managing self-care routines (4).

Fine motor skills are essential for daily functioning and academic success, with strong relationships observed between fine motor skills, learning capacity, and communication abilities (5, 6). They are also correlated with functional performance in self-care, mobility, and social interactions (7, 8). Impairments in fine motor function can hinder daily tasks such as dressing and writing (9). Given that children spend up to 60% of their school time engaged in fine motor activities, such impairments can significantly affect their academic achievement (10).

Beyond fine motor skills, activities of daily living (ADLs) require the integration of motor, cognitive, and socio-emotional abilities (11, 12). Many ADLs require simultaneous motor and cognitive skills, underscoring their complexity, which includes fundamental tasks such as bathing, grooming, dressing, toileting, transferring, and eating. Research indicates a strong association between executive functions (EF) and ADLs (13, 14). Children with SLD often experience difficulties with EF, which encompasses cognitive, metacognitive, and self-regulatory processes that develop during childhood, primarily associated with prefrontal cortex functions (15). Deficits in EF can lead to attention issues, planning difficulties, learning challenges, academic setbacks, and problems with dual-tasking (16, 17). The ability to perform ADLs independently is crucial for a child's health, well-being, and development, all of which rely on cognitive and motor skills influenced by social and environmental factors (18).

Dual and multiple motor tasks, in particular, are essential for maintaining effective daily functioning and facilitating successful participation in everyday routines (19, 20). Similar to adults, children frequently engage in multitasking to carry out daily activities independently (21).

However, managing multiple tasks can be challenging for them, as performing a secondary task simultaneously may compromise their success with the primary task (19).

The dual-task paradigm provides a valuable framework for evaluating individual performance under simultaneous dual-task conditions compared to single-task conditions. It serves two primary purposes: assessing the attentional demands of the motor tasks and exploring how concurrent cognitive or motor tasks influence motor performance (22).

Research on dual-task performance in children with SLD has predominantly focused on gross motor skills (23-26). These skills have been identified as potential predictors of early learning disabilities (23), with postural control and balance being the most frequently examined components (24, 25). While these findings provide valuable insights, fine motor skills are equally critical. They are strong predictors of academic success, as classroom achievement heavily relies on children's ability to perform fine movements (27, 28). Furthermore, fine motor competence enhances quality of life and supports future participation in activities for students with special educational needs (29). Despite their importance, fine motor skills- particularly under dual-task conditions-remain underexplored in children with SLD. Therefore, the aim of this study was to compare the single and dual-task fine motor performance of children with SLD to that of their typically developing peers and to examine its association with their level of participation in activities of daily living, thereby addressing a critical gap in the current literature.

Methods

This cross-sectional comparative study aimed to evaluate fine motor performance in children with SLD compared to their typically developing peers under both single- and dual-task conditions. Additionally, it sought to investigate the association between task performance and participation in everyday activities.

Participants

A total of 62 students diagnosed with SLD and 62 typically developing peers were recruited through convenience sampling from rehabilitation centers and elementary schools in Tehran, between February and October 2025. To account for the potential influence of socioeconomic status and residential location on children's participation, Tehran was initially stratified into five districts (north, south, east, west, and center) (30), and participants were subsequently recruited through convenience sampling from one school within each district.

The sample size estimation was based on values reported by Findik, who identified mean ± SD Purdue Pegboard Test (both-hands) scores of 11.66 ± 1.81 in children with SLD and 13.13 ± 3.10 in their TD peers (4). Using this effect size with a 95% confidence level and 90% power, the required sample size was determined to be 62 participants per group.

Children aged 8 to 11 years with a confirmed diagnosis of SLD by a psychiatrist were included in the study. Exclusion criteria included visual or auditory impairments, coexisting medical conditions (e.g., autism spectrum disorder), and upper limb orthopedic conditions that could interfere with test performance. Typically developing children attending mainstream schools were also recruited, provided they met the same exclusion criteria.

Procedure

At the outset of the study, informed consent was obtained from the parents, who were assured of their privacy and confidentiality. Demographic characteristics of the participants, including age, sex, educational background, and dominant hand, were collected through a structured, researcher-designed questionnaire. Fine motor performance, serving as the independent variable, was assessed using the Purdue Pegboard Test (PPT) under both single- and dual-task conditions. The dual-task conditions were designed to simulate real-life multitasking demands and to evaluate the

[DOI: 10.47176/mjiri.40.73]

influence of cognitive load on fine motor performance. Participation in activities of daily living, considered the dependent variable, was measured using the Jebsen Taylor Hand Function Test (JTHFT).

All assessments in both groups were conducted by an experienced occupational therapist specializing in pediatric learning disabilities. To minimize potential distractions, evaluations were performed in a controlled environment with regulated lighting and auditory conditions to enhance concentration and engagement. Structured rest breaks were provided for participants exhibiting signs of fatigue or reduced attention, ensuring comfort and sustained engagement throughout the assessment process.

Purdue Pegboard test (PPT): Fine motor skills were evaluated using the Purdue Pegboard Test (PPT). For the single-task assessment, participants used their dominant hand to place as many pegs as possible within a 30-second interval. Dual-task performance was evaluated in two conditions: motor-motor and motor-cognitive tasks. The motor-motor task comprised a bilateral subtest in which participants placed pegs simultaneously with both hands, and the total number of pegs placed was recorded. In the motor-cognitive task, participants placed pegs with their dominant hand while concurrently counting backward (31). The PPT is a widely used and efficient tool for assessing fine motor function across clinical and industrial settings (32).

Jebsen-Taylor Hand Function Test (JTHFT): The Jebsen–Taylor Hand Function Test (JTHFT) is a standardized assessment designed to provide quantitative measures of various aspects of hand function relevant to activities of daily living. It comprises seven timed tasks—writing, card turning, picking up small and large light objects, picking up large heavy objects, simulated feeding, and stacking checkers—thereby capturing a broad range of functional abilities (33). In this study, participants completed the JTHFT using their dominant hand. The test score included the time required to complete each task (subtest) as well as the total time across all tasks. Lower scores (shorter completion times) indicate better hand function in ADLs, while higher scores (longer completion times) reflect poorer performance. The test has demonstrated high test–retest reliability in typically developing children aged 6–10 years, with normative values established by age and gender (34).

Statistical analysis

Continuous variables were summarized as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. For variables that met normality assumptions, independent t-tests were used for group comparisons and Mann–Whitney U tests for non-normal count variables (e.g., correct and incorrect responses). Because the study was exploratory, no multiple-comparison correction (e.g., Bonferroni, Holm, FDR) was applied, and p-values were interpreted cautiously. Correlation and regression analyses were conducted separately for each fine motor variable using simple/bivariate linear regression. Analyses were performed on the pooled sample of 124 participants, and regression assumptions were verified. Statistical significance was established at $P<0.05$, and analyses were conducted using SPSS Version 26 (IBM Corporation).

Results

A total of 124 children participated in this study, comprising 62 diagnosed with specific learning disabilities (SLD) and 62 typically developing peers, all aged between 8 and 11 years. The mean age of children was 9.44 ± 1.01 years in the SLD group and 9.38 ± 1.03 years in the typically developing group. In the SLD group, 59.7% of participants were male, whereas the control group exhibited an equal gender distribution (50% male). Most students in the SLD group were in third grade (approximately one-third), followed by fourth grade (28.2%), second grade (21%), and fifth grade (16.1%). Similarly, in the typically developing group, the majority were in third grade (approximately one-third), followed by fourth grade (30.6%), second grade (22.6%), and fifth grade (14.5%). Right-handedness was prevalent in both groups 96.8% in the SLD group and 95.2% in the typically developing group (Table 1). Statistical analysis revealed no significant differences between the groups across demographic variables, indicating comparability in these characteristics ($P>0.05$). All children diagnosed with SLD were classified as having the mixed, type of the disorder.

Comparison of Fine Motor Performance under Single and Dual Tasks: Children with SLD exhibited significantly lower performance on single-task activities, irrespective of the hand used, compared to typically developing peers ($P < 0.05$). Dual-task conditions further highlighted group differences, with children with SLD performing markedly worse on both motor–motor and motor–cognitive tasks relative to their single-task performance ($P<0.05$). These deficits were evident in key indicators such as the number of pegs placed, response accuracy, and error frequency

Table 1. Demographic characteristics of participants (n=124)

Characteristics		SLD group (n=62)	TD group (n=62)	*P*-value
Age (years)		9.44 ± 1.01	9.38 ± 1.03	0.753
Sex (n)	Boy	59.7% (37)	50% (31)	
	Girl	40.3% (25)	50% (31)	0.283
Grade (n)	2	21% (12)	22.6% (14)	
	3	34.7% (23)	32.3% (20)	
	4	28.2% (16)	30.6% (19)	0.788
	5	16.1% (11)	14.5% (9)	
Dominant hand (n)	Right	96.8% (59)	95.2% (58)	
	Left	3.2% (3)	4.8% (4)	0.651

SLD: Specific Learning Disability; TD: Typically Developing.

[DOI: 10.47176/mjiri.40.73]

Table 2. Performance characteristics of participants (n=124)

Characteristics		SLD group (mean ± SD)	TD group (mean ± SD)	*P*-value
Single task	Dominant hand (pin numbers)	11.64 ±1.6	14.68 ± 2.3	< 0.001
	Non-dominant hand (pin numbers)	9.35 ± 2.1	12.84 ± 1.7	< 0.001
Dual task	Motor- motor (pin numbers)	7.1 ± 1.5	8.9 ± 1.6	< 0.001
	Motor-cognitive (pin numbers)	10.2 ± 1.4	13.3 ± 2.3	< 0.001
	Correct answers (number)	8.7 ± 1.7	12.4 ± 2.5	< 0.001
	Wrong answers (number)	1.4 ± 1	0.9 ± 0.9	0.003
Jebsen-Taylor Hand Function Test	Writing (seconds)	4289.9 ± 984.8	2173 ± 902	< 0.001
	Simulated Page Turning (seconds)	598.9 ± 118.3	392.1 ± 97.6	< 0.001
	Small Common Objects (seconds)	445.6 ± 107.6	309.7 ± 85.6	< 0.001
	Simulated Feeding (seconds)	363.5 ± 76.5	286.3 ± 75.3	0.09
	Stacking Checkers (seconds)	412.6 ± 75.3	273.2 ± 133.7	0.06
	Moving Large Light Objects (seconds)	797.2 ± 68.9	706.2 ± 98.7	0.01
	Moving Large Heavy Objects (seconds)	949.3 ± 123.6	789.3 ± 109.1	< 0.001
	Total score	7857.3 ± 1020.9	4929.9 ± 1229.9	< 0.001

SLD: Specific Learning Disability; TD: Typically Developing.

Table 3. Bivariate associations between fine motor performance variables and JTHFT scores in participants (N = 124)

Characteristic		Correlation		Regression			
		Pearson	*P*-value	B	*P*-value	CI	
Single task	Dominant hand (Pin numbers)	-0.109	0.397	-41.9	0.763	-319.5	235.6
	Non-dominant hand (Pin numbers)	-0.170	0.187	-159.5	0.197	-404.5	85.4
Dual task	Motor- motor (Pin numbers)	-0.062	0.630	-34.7	0.760	-262	192.5
	Motor-cognitive (Pin numbers)	-0.053	0.683	79.8	0.532	-174.5	334.2
	Correct answers (Number)	0.005	0.971	2.8	0.971	-153.1	158.9
	Wrong answers (Number)	-0.113	0.380	-214.4	0.155	-512.7	83.7

(P<0.001), underscoring the detrimental impact of additional cognitive or motor demands (Table 2).

Comparison of participation in activities of daily living between groups: As indicated in Table 2, children with SLD exhibited significantly lower overall performance on the JTHFT and the majority of subtests. However, no significant group differences were observed in the simulated feeding and checker-stacking tasks.

Association between Task Performance and Participation: Although several single- and dual-task measures exhibited negative correlations with participation, none were statistically significant (P>0.05). Regression analyses similarly confirmed that task performance did not predict participation in activities of daily living (Table 3).

Discussion

The present study compared fine motor performance in children with specific learning disabilities (SLD) to that of their typically developing peers, focusing on both single- and dual-task conditions. It also examined participation in activities of daily living and the associations between performance and participation. Children with SLD exhibited significantly poorer performance under both single-task and dual-task conditions and demonstrated lower levels of participation. However, no significant associations were found between fine motor performance and participation, suggesting that participation is influenced by multiple interacting factors beyond motor skills alone.

Numerous studies have demonstrated that children with SLD tend to perform poorly on fine motor activities (3, 35-37). For example, Findik et al. reported that children with SLD scored lower than their typically developing peers on the assembly subtests of the Purdue Pegboard Test (PPT), a result consistent with our findings (4). In the present study, children with SLD exhibited significantly poorer performance on both single- and dual-task manual activities, with the most pronounced deficits observed under dual-task conditions. These results suggest that increased cognitive or motor demands may exacerbate underlying difficulties in motor coordination, highlighting this population's sensitivity to cognitive load. This observation corroborates previous research, including studies by Getchell et al. (23), Karabulut et al. (25), Horata and Kundakci (26), and Legrand et al. (24), all of which consistently reported functional deficits in gross dual-motor tasks, particularly in postural balance, among children with SLD. Taken together, these findings reinforce the notion that dual-task demands impose a disproportionate burden on motor coordination in this population, highlighting the interaction between cognitive load and motor control. The execution of dual tasks underscores the essential role of cognitive processes in managing activities of daily living (26). Cognitive impairment is a fundamental characteristic of children with SLD, with executive functions—most notably working memory—adversely affected (16). Executive functioning enables individuals to pause, evaluate, and adapt to novel or unexpected situations (16, 38). The significant decline observed under dual-task conditions in our study aligns with previous research indicating that children with SLD often struggle with divided attention, working memory, and motor planning. Since dual-tasking requires the simultaneous engagement of multiple cognitive and motor systems, the impairments identified may reflect limitations in resource allocation and task-switching abilities. These challenges are particularly relevant in classroom environments, where children are frequently required to manage competing demands, such as listening, writing, and responding to instructions simultaneously.

Research indicates a strong association between fine motor skills and executive functions, as well as broader

[DOI: 10.47176/mjiri.40.73]

cognitive abilities (39). The acquisition of fine motor skills has been recognized as an effective strategy for enhancing working memory, problem-solving, and inhibitory control in students with SLD (40, 41). In our study, reduced performance on single-hand tasks—regardless of hand dominance—suggests that fine motor difficulties in children with SLD are not limited to complex or cognitively demanding situations. Rather, these challenges may reflect fundamental deficits in motor planning and execution. This interpretation aligns with previous findings linking SLD to developmental coordination disorder (DCD) and other motor-based learning difficulties (42), reinforcing the notion that motor impairments in this population are pervasive and multifactorial.

Notably, children with SLD demonstrated lower overall participation compared to their typically developing peers; however, no significant performance differences were observed in two subtests—simulated feeding and stacking checkers. These findings suggest that children with SLD frequently engage in and practice routine activities of daily living, enabling them to perform these tasks at a level comparable to that of their peers. Despite significant group differences in both participation and fine motor performance under single- and dual-task conditions, the present study did not reveal a significant correlation between task performance and participation, as measured by the JTHFT. This finding may underscore the multifactorial nature of participation, which is influenced not only by motor abilities but also by broader personal, environmental, and contextual factors. It underscores the need for future studies to explore mediating variables such as environmental supports, motivation, and adaptive strategies.

The implications of these findings are particularly relevant for educational and therapeutic settings. Given the integral role of fine motor skills in academic tasks such as handwriting, drawing, and manipulating classroom tools, early identification and intervention targeting motor development could be crucial for supporting academic achievement in children with SLD. Interdisciplinary approaches involving teachers, occupational therapists, and psychologists may be especially beneficial in addressing both cognitive and motor dimensions of learning difficulties.

This study is the first to investigate fine motor dual-task performance in children with SLD. While the findings provide new insights, several limitations should be acknowledged. First, the use of convenience sampling and the cross-sectional design may restrict the generalizability of the results. Second, although the study aimed to examine participation, the JTHFT is a timed hand-function test that evaluates motor capacity in simulated tasks rather than participation as defined by the ICF. In this study, the JTHFT served only as a proxy for participation because its subtests reflect performance on ADL-related tasks; however, it does not capture actual participation in daily contexts. Future studies should employ longitudinal designs and incorporate validated participation instruments such as the PEM-CY or CASP to more accurately assess participation and its determinants.

Conclusion

Children with specific learning disabilities (SLD) exhibit significant fine motor difficulties, particularly under dual-task conditions, and demonstrate lower levels of participation compared to their typically developing peers. However, the lack of significant associations between single- or dual-task fine motor performance and participation underscores the multifactorial nature of engagement in activities of daily living. These findings highlight the necessity for future research to investigate additional personal and contextual factors that may influence participation.

Acknowledgment

The authors sincerely thank the children who participated in this study, as well as their parents, teachers, and the staff of the contributing schools. Their cooperation and support made this research possible.

Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contributions

M. Hejazi-Shirmard and S. Zamiran conceptualized and designed the study, prepared the initial manuscript draft, and contributed to manuscript revisions. M. Hejazi-Shirmard supervised the research process. S. Zamiran and A. Nasiri contributed to data collection. F. Zayeri conducted the statistical analyses and contributed to data interpretation. M. Nobahar contributed to the study methodology and assisted in drafting the initial manuscript.

Ethical Considerations

This study was ethically evaluated and approved by Ethics Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1403.757).

Funding Support

This study received no funding.

Data Availability

The data supporting this study are available from the corresponding author only on reasonable request.

AI Use Statement

Artificial intelligence tools were not used for data collection, data analysis, or interpretation of results. Microsoft Copilot was used only for paraphrasing and language refinement during manuscript preparation

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[DOI: 10.47176/mjiri.40.73]