International Journal of Human Movement and Sports Sciences 14(1): 59-73, 2026 http://www.hrpub.org
DOI: 10.13189/saj.2026.140107

Neuroplasticity Potentials in Students with Disabilities: A Preliminary Study on Fine and Gross Motor Function before FITT-Based Intervention

Muh Isna Nurdin Wibisana[1,*], Muhammad Atiq Noviudin Pritama[2], Husnul Hadi[1]

[1]Physical Education, Health and Recreation, PGRI Semarang University, Indonesia
[2]Sports Coaching Education, State University of Malang, Indonesia

Received August 11, 2025; Revised December 12, 2025; Accepted January 12, 2026

Cite This Paper in the Following Citation Styles

(a): *[1] Muh Isna Nurdin Wibisana, Muhammad Atiq Noviudin Pritama, Husnul Hadi , "Neuroplasticity Potentials in Students with Disabilities: A Preliminary Study on Fine and Gross Motor Function before FITT-Based Intervention," International Journal of Human Movement and Sports Sciences, Vol. 14, No. 1, pp. 59 - 73, 2026. DOI: 10.13189/saj.2026.140107.*

(b): *Muh Isna Nurdin Wibisana, Muhammad Atiq Noviudin Pritama, Husnul Hadi (2026). Neuroplasticity Potentials in Students with Disabilities: A Preliminary Study on Fine and Gross Motor Function before FITT-Based Intervention. International Journal of Human Movement and Sports Sciences, 14(1), 59 - 73. DOI: 10.13189/saj.2026.140107.*

Copyright©2026 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract Neuroplasticity—the brain's capacity to reorganize and form new neural connections in response to experience—offers critical opportunities to enhance motor learning in students with disabilities. However, research in inclusive education rarely integrates baseline motor mapping as a foundation for neuroplasticity-based intervention design. This preliminary study aimed to assess the fine and gross motor functions of students with disabilities prior to implementing a FITT (Frequency, Intensity, Time, Type) principle-based exercise program. A descriptive quantitative design was applied to 187 students aged 7–10 years with mild intellectual and hearing disabilities enrolled in inclusive and special schools in Semarang, Indonesia. Fine motor coordination was measured using the Nine Hole Peg Test (NHPT), while gross motor performance was evaluated through the locomotor subtest of the Test of Gross Motor Development–Second Edition (TGMD-2). Data were analyzed descriptively and inferentially using the Kruskal–Wallis test. Results revealed overall low motor performance across both domains. The mean NHPT completion time among students with intellectual disabilities was 41.29 ± 21.11 s for males and 49.71 ± 32.79 s for females, whereas the mean TGMD-2 locomotor scores averaged 14.68 ± 7.56 and 14.11 ± 8.47, respectively. Significant differences were observed in fine motor performance among male groups ($p < 0.05$), but no significant variation was found in locomotor abilities. These findings indicate delayed manual dexterity and limited coordination likely due to reduced sensorimotor stimulation and minimal engagement in structured physical activities. The study emphasizes that baseline motor mapping should serve as a prerequisite for individualized FITT-based interventions in inclusive schools. Establishing early motor profiles enables the development of adaptive, evidence-based programs that leverage neuroplasticity to enhance functional independence, classroom participation, and quality of life. Despite its pretest-only limitation, this study contributes to bridging the gap between educational practice and neurophysiological theory, providing a practical framework for integrating motor assessment and personalized training within inclusive education settings in Indonesia.

Keywords Neuroplasticity, Disability, Fine Motor, Gross Motor, FITT Training

---

1. Introduction

Neuroplasticity—the brain's capacity to reorganize structurally and functionally in response to experience,

activity, or injury—has become a key concept in improving the quality of life of individuals with disabilities [1]. In inclusive education, this concept is critical because students with disabilities often experience challenges in motor, cognitive, and sensory domains that directly affect their participation in learning and daily life [2, 3]. According to the International Classification of Functioning, Disability and Health (ICF), interventions for such students should enhance both bodily function and participation in everyday activities [4].

Motor functions—fine and gross—are fundamental indicators of children's ability to act independently and engage in learning environments [5]. Fine motor skills involve precise movements such as grasping or writing, while gross motor skills encompass broader movements such as running, jumping, and balancing [6]. Limitations in either aspect can hinder academic performance and psychosocial development [7]. Validated instruments like the Nine Hole Peg Test (NHPT) for fine motor assessment and the Test of Gross Motor Development, Second Edition (TGMD-2) for gross motor skills are widely used in pediatric and disability research [1, 8].

Recent studies emphasize that neuroplasticity can be stimulated through structured, intensive, and meaningful motor activities [9, 10]. Likewise, movement-based interventions following the FITT (Frequency, Intensity, Type, Time) framework have been shown to enhance motor competence and neural efficiency. The FITT principle provides a flexible yet systematic approach for tailoring exercise intensity and type according to each individual's capacity [11].

However, despite increasing evidence on the neuroplastic effects of FITT-based programs, research integrating baseline motor function mapping before such interventions—particularly in low-resource inclusive education contexts—is still scarce. Most prior studies focus on post-intervention outcomes, overlooking the diagnostic value of pre-intervention motor profiling as a foundation for individualized exercise design. This gap is especially relevant in Indonesia, where inclusive schools often lack structured motor assessments or trained specialists [12]. As a result, interventions tend to be generic and fail to address students' neurofunctional diversity.

Nationally, policies such as *Permendikbud No. 70/2009 on Inclusive Education* have strengthened the commitment to equitable learning opportunities. Yet, their practical implementation remains limited, especially in linking physical-motor development with classroom pedagogy. Establishing evidence-based baseline assessments could therefore bridge this gap—supporting both adaptive teaching and rehabilitation strategies grounded in neuroplasticity principles.

Accordingly, this study aims to analyze the fine and gross motor function profiles of students with disabilities prior to FITT-based training, using standardized instruments (NHPT and TGMD-2 locomotor subtest). By providing an empirical foundation for individualized program design, this preliminary study contributes to developing neuroplasticity-oriented interventions that are pedagogically relevant and contextually feasible for inclusive education settings in Indonesia.

2. Materials and Methods

This study employed a descriptive quantitative design with a preliminary study approach. The primary aim was to test and refine the study procedures, evaluate the feasibility of participant recruitment, and ensure the reliability of the instruments before conducting a larger experimental study [13].

The preliminary study specifically aimed to map fine and gross motor functions in students with disabilities prior to the implementation of an exercise intervention based on the FITT (Frequency, Intensity, Time, Type) principles [14]. The main focus of this design was to obtain an initial profile of participants' motor abilities as a foundation for developing personalized exercise programs grounded in neuroplasticity potential.

2.1. Participants

Participants in this study were students with disabilities aged 7–10 years enrolled in inclusive and special elementary schools in Semarang City, Indonesia. The sampling technique employed was purposive sampling, chosen because the research targeted specific disability categories that met the inclusion criteria and aligned with the objectives of the preliminary phase [15].

Schools were approached through collaboration with the Semarang City Education Office and the principals of inclusive and special schools. Researchers held coordination meetings with teachers and parents, distributed information sheets, and obtained written informed consent from parents or guardians before testing began.

The inclusion criteria were as follows: Diagnosed with mild intellectual disability or mild hearing impairment, based on school records supported by psychological or audiological assessments [16]; able to follow simple verbal or gestural instructions; provided written parental/guardian consent to participate. The final sample consisted of 187 participants from eight schools, distributed as follows: Children with mild intellectual disabilities: 145 (90 boys, 55 girls). Children with mild hearing impairments: 42 (25 boys, 17 girls)

2.2. Instruments

Two standardized and internationally validated instruments were used to measure fine and gross motor function, respectively:

(a) Fine Motor Function – Nine Hole Peg Test (NHPT)

Fine motor coordination and dexterity were assessed using the Nine Hole Peg Test (NHPT). Each participant

was instructed to insert and remove nine pegs from a board with nine holes as quickly as possible [17].

The test was administered individually in a quiet setting to minimize distractions. Each child performed one practice trial followed by one timed test trial for each hand. Testing began with the dominant hand, followed by the non-dominant hand. The completion time (in seconds) was recorded with a stopwatch.

Scoring followed the standardized normative data, which adjusts performance by age and gender, with shorter completion times indicating better performance. This test has been widely used for children with neurological or developmental conditions and is known for its high test–retest reliability (r = 0.91–0.97) [18].

(b) Gross Motor Function – Test of Gross Motor Development

Second Edition (TGMD-2; Locomotor Subtest Only) Gross motor skills were measured using the locomotor subtest of the Test of Gross Motor Development – Second Edition (TGMD-2). This subtest evaluates six fundamental movement skills: run, gallop, hop, leap, horizontal jump, and slide, which collectively represent locomotor coordination and lower-body motor integration [6].

The object control (manipulative) subtest was not included in this study for the following scientific and methodological reasons: Focus on Neuroplastic and Fundamental Motor Pathways. Locomotor movements primarily reflect core neuromotor integration between cortical and subcortical regions responsible for balance, coordination, and rhythmic movement [1]. These are considered foundational indicators of neuroplastic potential.

In contrast, object control skills (e.g., throwing, catching) involve additional perceptual–cognitive processing and hand–eye coordination, which are not central to the preliminary objective of mapping basic motor capacity.

Feasibility and Comprehension in Populations with Disabilities. During pilot observations, participants with mild intellectual and hearing disabilities demonstrated difficulty understanding multi-step manipulative tasks, leading to inconsistent data quality. Locomotor tasks, being more universally familiar and less cognitively demanding, ensured higher reliability and validity of responses across participants.

Ecological and Functional Relevance. Locomotor skills are core to daily functional mobility and participation in school-based physical activities. Hence, the locomotor domain was prioritized as the most ecologically relevant aspect of gross motor performance in the inclusive education context.

Practical Considerations in Preliminary Testing. Given the large sample size (n = 187) and time constraints during school hours, limiting the TGMD-2 assessment to the locomotor domain minimized participant fatigue and testing duration, while still capturing the essential dimension of gross motor proficiency.

The TGMD-2 locomotor test was administered individually by trained researchers with backgrounds in physical education and occupational therapy. Each child performed two trials per skill, which were videotaped for later scoring according to the TGMD-2 manual.

Each correctly executed skill component received a score of “1”, while errors received “0”. Inter-rater reliability was ensured through cross-checking of 20% of video samples by two independent raters (r = 0.93) [6].

2.3. Classification Criteria

Motor performance levels were classified based on published normative data from each instrument. For NHPT, the raw completion times were converted into standardized z-scores according to age- and gender-based norms. For TGMD-2 (Locomotor Subtest), raw scores were converted into standard scores and descriptive ratings (Very Poor, Poor, Below Average, Average, Above Average, Superior) following the official TGMD-2 manual.

To facilitate interpretation, the descriptive ratings were grouped into three broader categories [18]:

- *Low* = Very Poor / Poor
- *Medium* = Below Average / Average
- *Good* = Above Average / Superior

2.4. Procedure

Data collection was conducted during regular school hours between 08:00 and 11:00 a.m., in coordination with classroom teachers and special education staff.

Each participant was tested individually in a calm and non-competitive atmosphere to reduce anxiety and ensure authentic performance. Each session lasted approximately 15–20 minutes per student, including short rest intervals between the NHPT and TGMD-2 assessments.

Environmental conditions (lighting, temperature, and noise) were controlled as much as possible. The research team maintained observation notes on each participant’s motivation, attention span, and environmental influences that could affect test performance.

All testing procedures adhered to ethical guidelines for research involving human participants, with ethical clearance obtained from the university research ethics committee.

2.5. Data Analysis

Data were analyzed using both descriptive and inferential statistics. Descriptive analysis included the calculation of means, standard deviations, minimum–maximum scores, and categorical distributions to provide a general overview of participants’ fine and gross motor performance. Inferential analysis aimed to identify differences between groups based on gender and disability type.

Because the normality and homogeneity tests (Kolmogorov–Smirnov and Levene’s Test) indicated that the data did not meet the assumptions for parametric

analysis, a non-parametric Kruskal–Wallis H test was employed.

This test is the appropriate alternative to one-way ANOVA for non-normally distributed data, allowing comparison of median performance scores across multiple independent groups.

All analyses were performed using IBM SPSS Statistics version 26.0, with the significance level set at $p < 0.05$.

3. Result

The results of the data analysis revealed the levels of gross and fine motor skills among students with intellectual disabilities (mental retardation) and hearing impairments.

3.1. Results of the Locomotor Performance of Students with Intellectual Disabilities and Hearing Impairments

The following results describe the locomotor performance of students with intellectual disabilities from eight Special Schools (SLB), as presented in Table 1.

The analysis revealed an overall mean score of 14.68 with a standard deviation (SD) of 7.56, indicating that, in general, the level of gross motor skills among male students with intellectual disabilities was at a moderate category, with considerable variation both between individuals and across schools. Specifically, the highest mean scores were found in Group 5 (M = 21.23) and Group 8 (M = 21.00), while the lowest mean scores were observed in Group 1 (M = 9.20) and Group 2 (M = 9.67). These differences suggest that the level of gross motor skills varied substantially among schools.

The results of locomotor skill performance among female students with intellectual disabilities are presented in Table 2.

The overall mean score was 14.11 with a standard deviation (SD) of 8.47, indicating a moderate level of locomotor ability and a relatively wide variation among students. Across schools, the highest mean score was found in Group 5 (M = 20.10, SD = 6.27) and Group 8 (M = 16.56, SD = 10.06), while the lowest mean scores were observed in Group 1 (M = 2.20, SD = 2.68) and Group 3 (M = 6.00, SD = 3.46). These findings suggest considerable variability in locomotor skill performance between schools.

The descriptive statistical analysis was conducted to examine the motor performance of students with hearing impairments (tuna rungu) from two Special Schools (SLB). As shown in Table 3, the data include a total of 25 students, divided into two groups.

The overall mean score was 20.32, with a standard deviation (SD) of 7.81, indicating that students with hearing impairments generally demonstrated a moderate to high level of motor performance, with some variation across individuals. Specifically, Group 1 recorded a mean score of 10.33 (SD = 0.82), while Group 2 achieved a considerably higher mean score of 23.47 (SD = 6.12). This substantial difference suggests that the students in Group 2 exhibited stronger motor abilities than those in Group 1.

The descriptive statistical analysis of female students with hearing impairments (tuna rungu) from two Special Schools (SLB) is presented in Table 4. A total of 17 students participated in this category.

The overall mean score was 20.65, with a standard deviation (SD) of 7.66, indicating that the average motor skill performance of female students with hearing impairments was in the moderate to high range, with some variability between individuals. Specifically, Group 1 recorded a mean score of 11.20 (SD = 1.79), while Group 2 achieved a notably higher mean score of 24.58 (SD = 5.18). This large difference suggests that students in Group 2 demonstrated considerably stronger motor skill abilities compared to those in Group 1.

Table 1. Descriptive Results of Locomotor Skill Performance in Male Students with Intellectual Disabilities

Descriptives								
SCORE								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	10	9.20	4.962	1.569	5.65	12.75	2	15
2	6	9.67	.816	.333	8.81	10.52	8	10
3	13	9.38	3.097	.859	7.51	11.26	4	16
4	8	15.75	2.866	1.013	13.35	18.15	12	20
5	26	21.23	6.843	1.342	18.47	23.99	9	32
6	14	10.71	5.902	1.577	7.31	14.12	2	20
7	6	12.33	4.633	1.892	7.47	17.20	4	16
8	7	21.00	8.926	3.374	12.75	29.25	5	32
Total	90	14.68	7.555	.796	13.10	16.26	2	32

Table 2. Descriptive Results of Locomotor Skill Performance in Female Students with Intellectual Disabilities

Descriptives								
SCORE								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	5	2.20	2.683	1.200	-1.13	5.53	0	6
2	3	10.67	1.155	.667	7.80	13.54	10	12
3	3	6.00	3.464	2.000	-2.61	14.61	2	8
4	4	14.50	3.697	1.848	8.62	20.38	9	17
5	20	20.10	6.274	1.403	17.16	23.04	10	32
6	5	10.00	5.477	2.449	3.20	16.80	6	16
7	6	9.33	5.750	2.348	3.30	15.37	2	16
8	9	16.56	10.064	3.355	8.82	24.29	0	27
Total	55	14.11	8.471	1.142	11.82	16.40	0	32

Table 3. Descriptive Results of Locomotor Skill Performance in Male Students with Hearing Impairments

Descriptives								
SCORE								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	6	10.33	.816	.333	9.48	11.19	10	12
2	19	23.47	6.123	1.405	20.52	26.42	8	30
Total	25	20.32	7.814	1.563	17.09	23.55	8	30

Table 4. Descriptive Results of Locomotor Skill Performance in Female Students with Hearing Impairments

Descriptives								
SCORE								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	5	11.20	1.789	.800	8.98	13.42	10	14
2	12	24.58	5.178	1.495	21.29	27.87	17	32
Total	17	20.65	7.664	1.859	16.71	24.59	10	32

3.2. Results of the Nine Hole Peg Test (NHPT) of Students with Intellectual Disabilities and Hearing Impairments

The results of the Nine Hole Peg Test (NHPT) provide an assessment of fine motor coordination and dexterity in students with intellectual disabilities and hearing impairments. The NHPT measures the time required to place and remove pegs from a pegboard, allowing researchers to compare the manual dexterity performance between different groups. These results are useful for identifying motor skill strengths and areas needing intervention in this population.

The descriptive results of the Nine Hole Peg Test (NHPT) for male students with intellectual disabilities are presented in Table 5.

The descriptive statistics table presents the mean, standard deviation, and score range of NHPT performance among students with intellectual disabilities and hearing impairments across eight groups. The mean scores vary considerably between groups, indicating differences in fine motor performance levels.

Group 2 recorded the highest mean score (M = 68.67, SD = 44.99), suggesting lower fine motor coordination or slower task completion time compared to other groups, while Group 5 had the lowest mean score (M = 33.31, SD = 12.84), indicating better performance. The total mean score across all participants was 41.29 (SD = 21.11), with scores ranging from 0 to 139.

The descriptive results of the Nine Hole Peg Test (NHPT) for female students with intellectual disabilities are presented in Table 6.

Table 5. Descriptive Results of the Nine Hole Peg Test (NHPT) in Male Students with Intellectual Disabilities

Descriptives								
Score								
					95% Confidence Interval for Mean		Minimum	Maximum
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound		
1	10	31.90	13.568	4.291	22.19	41.61	17	60
2	6	68.67	44.992	18.368	21.45	115.88	31	139
3	13	40.46	17.681	4.904	29.78	51.15	26	92
4	8	50.75	26.932	9.522	28.23	73.27	28	110
5	26	33.31	12.837	2.517	28.12	38.49	0	67
6	14	51.93	18.681	4.993	41.14	62.71	29	97
7	6	34.17	8.232	3.361	25.53	42.81	26	48
8	7	36.43	6.477	2.448	30.44	42.42	30	50
Total	90	41.29	21.112	2.225	36.87	45.71	0	139

Table 6. Descriptive Results of the Nine Hole Peg Test (NHPT) in Female Students with Intellectual Disabilities

Descriptives								
Score								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	5	37.60	13.667	6.112	20.63	54.57	17	47
2	3	102.33	89.019	51.395	-118.80	323.47	34	203
3	3	43.33	17.954	10.366	-1.27	87.93	23	57
4	4	41.50	6.455	3.227	31.23	51.77	36	50
5	20	51.15	28.100	6.283	38.00	64.30	26	124
6	5	67.80	50.524	22.595	5.07	130.53	29	150
7	6	35.00	10.658	4.351	23.81	46.19	24	53
8	9	41.22	15.222	5.074	29.52	52.92	23	70
Total	55	49.71	32.789	4.421	40.84	58.57	17	203

The descriptive statistics table displays the mean, standard deviation, and range of NHPT scores across eight groups of students with intellectual disabilities and hearing impairments. The results show substantial variation in mean scores, reflecting differences in fine motor coordination among the groups.

The highest mean score was observed in Group 2 (M = 102.33, SD = 89.02), indicating that this group required more time to complete the NHPT, thus suggesting weaker fine motor control. Conversely, the lowest mean score was found in Group 1 (M = 37.60, SD = 13.67), implying relatively better fine motor performance.

The descriptive results of the Nine Hole Peg Test (NHPT) for male students with hearing impairments are presented in Table 7.

The descriptive statistics table summarizes the NHPT scores of male students with intellectual disabilities across two groups. The data show differences in average performance levels, as reflected in the mean scores and variability. Group 1 recorded a mean score of 43.67 (SD = 15.37), with scores ranging from 24 to 64, indicating relatively slower completion times and lower fine motor coordination. In contrast, Group 2 had a lower mean score of 21.84 (SD = 3.39), ranging from 17 to 31, suggesting faster completion times and better fine motor control.

The descriptive results of the Nine Hole Peg Test (NHPT) for female students with hearing impairments are presented in Table 8.

The descriptive statistics table presents the NHPT scores of male students with intellectual disabilities divided into two groups. The results indicate variations in fine motor performance between the groups. Group 1 had a mean score of 37.60 (SD = 11.42), with scores ranging from 29 to 57, suggesting slower completion times and lower fine motor coordination. Meanwhile, Group 2 showed a lower mean score of 22.08 (SD = 6.20), with a range between 15 and 36, indicating faster task completion and better fine motor control.

Table 7. Descriptive Results of the Nine Hole Peg Test (NHPT) in Male Students with Hearing Impairments

Descriptives								
Score								
					95% Confidence Interval for Mean		Minimum	Maximum
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound		
1	6	43.67	15.371	6.275	27.54	59.80	24	64
2	19	21.84	3.387	.777	20.21	23.47	17	31
Total	25	27.08	12.179	2.436	22.05	32.11	17	64

Table 8. Descriptive Results of the Nine Hole Peg Test (NHPT) in Female Students with Hearing Impairments

Descriptives								
Score								
					95% Confidence Interval for Mean		Minimum	Maximum
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound		
1	5	37.60	11.415	5.105	23.43	51.77	29	57
2	12	22.08	6.201	1.790	18.14	26.02	15	36
Total	17	26.65	10.589	2.568	21.20	32.09	15	57

3.3. Results of Normality Test for Locomotor Skills Data of Students with Intellectual Disabilities and Hearing Impairments

The results of the normality test for the locomotor movement data of male students with intellectual disabilities across eight sample groups are presented in Table 9 below.

Table 9. Results of the Normality Test for Locomotor Skills Data of Male Students with Intellectual Disabilities

Group	N	Shapiro-Wilk Sig.	Normality Conclusion
1	10	0.184	Normal
2	6	0.000	Not normal
3	13	0.457	Normal
4	8	0.347	Normal
5	26	0.328	Normal
6	14	0.563	Normal
7	6	0.094	Normal
8	7	0.727	Normal

Based on the Shapiro–Wilk test, most groups show Sig. values greater than 0.05, indicating that their data are normally distributed. Only Group 2 has a Sig. value of 0.000, which means its data do not follow a normal distribution.

The results of the normality test for the locomotor movement data of female students with intellectual disabilities are presented in Table 10 below.

Table 10. Results of the Normality Test for Locomotor Skills Data of Female Students with Intellectual Disabilities

Group	N	Shapiro-Wilk Sig.	Normality Conclusion
1	5	0.201	Normal
2	3	0.000	Not normal
3	3	0.000	Not Normal
4	4	0.029	Not Normal
5	20	0.434	Normal
6	5	0.006	Not Normal
7	6	0.343	Normal
8	9	0.075	Normal

The Shapiro–Wilk test shows that Groups 1, 5, 7, and 8 have Sig. values greater than 0.05, indicating that their data are normally distributed. In contrast, Groups 2, 3, 4, and 6 have Sig. values less than 0.05, meaning their data are not normally distributed.

The results of the normality test for the locomotor movement data of male students with hearing impairments are presented in Table 11 below.

Table 11. Results of the Normality Test for Locomotor Skills Data of Male Students with Hearing Impairments

Group	N	Shapiro-Wilk Sig.	Normality Conclusion
1	6	0.000	Not Normal
2	19	0.011	Not normal

As shown in Table 11, the Shapiro–Wilk test results

revealed significance values of p = 0.000 for Group 1 and p = 0.011 for Group 2. Since all significance values are less than 0.05, this indicates that the locomotor data for both groups are not normally distributed.

The results of the normality test for the locomotor movement data of female students with hearing impairments are presented in Table 12 below.

Table 12. Results of the Normality Test for Locomotor Skills Data of Female Students with Hearing Impairments

Group	N	Shapiro-Wilk Sig.	Normality Conclusion
1	5	0.046	Not Normal
2	12	0.459	Normal

The results of the normality test for the locomotor movement data of female students with hearing impairments are shown in Table 12. The Shapiro–Wilk test indicated that Group 1 had a significance value of p = 0.046, which is below 0.05, suggesting that the data were not normally distributed. Meanwhile, Group 2 had a significance value of p = 0.459, which is greater than 0.05, indicating that the data were normally distributed. Therefore, only the data from Group 2 met the assumption of normality.

3.4. Results of Normality Test for the Nine Hole Peg Test (NHPT) of Students with Intellectual Disabilities and Hearing Impairments

The results of the normality test for the NHPT data of male students with intellectual disabilities are presented in Table 13 below.

Table 13. Results of the Normality Test for the Nine Hole Peg Test (NHPT) of Male Students with Intellectual Disabilities

Group	N	Shapiro-Wilk W	Sig.	Normality Conclusion
1	10	0.916	0.327	Normal
2	6	0.811	0.073	Normal
3	13	0.728	0.001	Not Normal
4	8	0.793	0.024	Not Normal
5	26	0.918	0.040	Not Normal
6	14	0.899	0.108	Normal
7	6	0.914	0.466	Normal
8	7	0.808	0.049	Not Normal

Based on the Shapiro–Wilk test, some groups show normally distributed data (Groups 1, 2, 6, 7), while other groups are not normally distributed (Groups 3, 4, 5, 8). This indicates that the normality assumption is not fully met, and non-parametric tests, such as the Kruskal–Wallis test, should be considered for further analysis.

The results of the normality test for the NHPT data of female students with intellectual disabilities are presented in Table 14 below.

Table 14. Results of the Normality Test for the Nine Hole Peg Test (NHPT) of Female Students with Intellectual Disabilities

Group	N	Shapiro-Wilk W	Sig.	Normality Conclusion
1	5	0.774	0.049	Not Normal
2	3	0.901	0.389	Normal
3	3	0.897	0.375	Normal
4	4	0.902	0.442	Normal
5	20	0.769	0.000	Not Normal
6	5	0.816	0.109	Normal
7	6	0.904	0.400	Normal
8	9	0.932	0.502	Normal

Based on the Shapiro–Wilk test, most groups (Groups 2, 3, 4, 6, 7, and 8) show normally distributed data, while Groups 1 and 5 are not normally distributed. This suggests that the normality assumption is mostly met, but the presence of non-normal groups indicates that non-parametric tests (such as the Kruskal–Wallis test) may still be appropriate for confirming the results.

The results of the normality test for the NHPT data of male students with hearing impairments are presented in Table 15 below.

Table 15. Results of the Normality Test for the Nine Hole Peg Test (NHPT) of Male Students with Hearing Impairments

Group	N	Shapiro-Wilk W	Sig.	Normality Conclusion
1	6	0.922	0.519	Normal
2	19	0.925	0.138	Normal

Based on the Shapiro–Wilk test, both groups show significance values greater than 0.05, indicating that the data in Groups 1 and 2 are normally distributed. Therefore, the assumption of normality is met, and parametric statistical tests can be appropriately used for further analysis.

The results of the normality test for the NHPT data of female students with hearing impairments are presented in Table 16 below.

Table 16. Results of the Normality Test for the Nine Hole Peg Test (NHPT) of Female Students with Hearing Impairments

Group	N	Shapiro-Wilk W	Sig.	Normality Conclusion
1	5	0.810	0.097	Normal
2	12	0.896	0.140	Normal

Based on the Shapiro–Wilk test, both groups show significance values greater than 0.05, indicating that the data in Groups 1 and 2 are normally distributed. Therefore, the normality assumption is fulfilled, and parametric tests can be appropriately applied for further analysis.

3.5. Results of Homogeneity Test for Locomotor Skills Data of Students with Intellectual Disabilities and Hearing Impairments

The results of the homogeneity test for the locomotor skills data of male students with intellectual disabilities are presented in Table 17 below.

Table 17. Results of the Homogeneity Test for Locomotor Skills Data of Male Students with Intellectual Disabilities

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	4.946	7	82	.000
	Based on Median	3.753	7	82	.001
	Based on Median and with adjusted df	3.753	7	47.361	.003
	Based on trimmed mean	4.885	7	82	.000

Levene's Test for Equality of Variances shows that the significance value (Sig.) for all test bases (Mean, Median, and Trimmed Mean) is less than 0.05. This indicates that the variances are not homogeneous across groups. In other words, there are significant differences in variance among the locomotor movement scores of male students with intellectual disabilities.

The results of the homogeneity test for the locomotor skills data of female students with intellectual disabilities are presented in Table 18 below.

Table 18. Results of the Homogeneity Test for Locomotor Skills Data of Female Students with Intellectual Disabilities

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	2.886	7	47	.014
	Based on Median	1.333	7	47	.256
	Based on Median and with adjusted df	1.333	7	27.449	.273
	Based on trimmed mean	2.681	7	47	.020

The results of Levene's Test indicate that the significance values based on the Mean (Sig. = 0.014) and the Trimmed Mean (Sig. = 0.020) are less than 0.05, suggesting that the assumption of homogeneity of variances is violated for these measures. However, the significance values based on the Median (Sig. = 0.256) and the Adjusted Median (Sig. = 0.273) are greater than 0.05, indicating homogeneous variances under those conditions.

The results of the homogeneity test for the locomotor skills data of male students with hearing impairments are presented in Table 19 below.

Table 19. Results of the Homogeneity Test for Locomotor Skills Data of Male Students with Hearing Impairments

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	7.193	1	23	.013
	Based on Median	4.747	1	23	.040
	Based on Median and with adjusted df	4.747	1	18.332	.043
	Based on trimmed mean	5.873	1	23	.024

The results of Levene's Test show that the significance values based on the Mean (Sig. = 0.013), Median (Sig. = 0.040), Adjusted Median (Sig. = 0.043), and Trimmed Mean (Sig. = 0.024) are all less than 0.05. This indicates that the assumption of homogeneity of variances is violated.

The results of the homogeneity test for the locomotor skills data of female students with hearing impairments are presented in Table 20 below.

Table 20. Results of the Homogeneity Test for Locomotor Skills Data of Female Students with Hearing Impairments

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	6.341	1	15	.024
	Based on Median	5.181	1	15	.038
	Based on Median and with adjusted df	5.181	1	13.773	.039
	Based on trimmed mean	6.413	1	15	.023

The results of Levene's Test indicate that the significance values based on the Mean (Sig. = 0.024), Median (Sig. = 0.038), Adjusted Median (Sig. = 0.039), and Trimmed Mean (Sig. = 0.023) are all less than 0.05. This result suggests that the assumption of homogeneity of variances is not met.

3.6. Results of Homogeneity Test for the Nine Hole Peg Test (NHPT) of Students with Intellectual Disabilities and Hearing Impairments

The results of the homogeneity test for the Nine Hole Peg Test (NHPT) data of male students with intellectual disabilities are presented in Table 21 below.

Table 21. Results of the Homogeneity Test for the Nine Hole Peg Test (NHPT) Data of Male Students with Intellectual Disabilities

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	6.047	7	82	.000
	Based on Median	2.084	7	82	.054
	Based on Median and with adjusted df	2.084	7	26.830	.081
	Based on trimmed mean	5.321	7	82	.000

Based on the Levene's test for homogeneity of variances, the significance value based on the mean is 0.000, which is less than 0.05. This indicates that the variance among groups is not homogeneous. In other words, there are significant differences in variance across the groups.

The results of the homogeneity test for the Nine Hole Peg Test (NHPT) data of female students with intellectual disabilities are presented in Table 22 below.

Table 22. Results of the Homogeneity Test for the Nine Hole Peg Test (NHPT) Data of Female Students with Intellectual Disabilities

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	5.605	7	47	.000
	Based on Median	1.715	7	47	.129
	Based on Median and with adjusted df	1.715	7	13.245	.189
	Based on trimmed mean	5.068	7	47	.000

Based on the Levene's test for homogeneity of variances, the significance value based on the mean is 0.000, which is less than 0.05. This indicates that the variance among groups is not homogeneous. In other words, there are significant differences in variance across the groups.

The results of the homogeneity test for the Nine Hole Peg Test (NHPT) data of male students with hearing impairments are presented in Table 23 below.

Table 23. Results of the Homogeneity Test for the Nine Hole Peg Test (NHPT) Data of Male Students with Hearing Impairments

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	26.548	1	23	.000
	Based on Median	13.362	1	23	.001
	Based on Median and with adjusted df	13.362	1	7.243	.008
	Based on trimmed mean	26.264	1	23	.000

Based on the results of Levene's test, the significance value ($p < 0.05$) in all methods indicates that the data variances between groups are not homogeneous. This means there is a significant difference in variance between the two groups tested.

The results of the homogeneity test for the Nine Hole Peg Test (NHPT) data of female students with hearing impairments are presented in Table 24 below.

Table 24. Results of the Homogeneity Test for the Nine Hole Peg Test (NHPT) Data of Female Students with Hearing Impairments

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	1.625	1	15	.222
	Based on Median	.789	1	15	.388
	Based on Median and with adjusted df	.789	1	8.979	.398
	Based on trimmed mean	1.480	1	15	.243

Based on the results of Levene's test, the significance values are greater than 0.05 across all methods. This indicates that the data variances between the two groups are homogeneous.

3.7. Results of Analysis for Locomotor Skills Data of Students with Intellectual Disabilities and Hearing Impairments

The results of the Kruskal–Wallis test for the locomotor movement performance of male students with intellectual disabilities are presented in Table 25 below.

Table 25. Results of the Kruskal–Wallis test for the locomotor movement performance of male students with intellectual disabilities

Test Statistics[a,b]	
	Score
Kruskal-Wallis H	43.379
df	7
Asymp. Sig.	.000

a. Kruskal-Wallis Test

b. Grouping Variable: Group

The results of the Kruskal–Wallis test show a Chi-square (H) value of 43.379 with 7 degrees of freedom and a significance level (Asymp. Sig.) of 0.000. Since the significance value is less than 0.05, it can be concluded that there are significant differences in locomotor movement scores among the eight groups of male students with intellectual disabilities.

The results of the Kruskal–Wallis test for the locomotor movement performance of female students with intellectual disabilities are presented in Table 26 below.

Table 26. Results of the Kruskal–Wallis test for the locomotor movement performance of female students with intellectual

Test Statistics[a,b]	
	Score
Kruskal-Wallis H	28.191
df	7
Asymp. Sig.	.000

a. Kruskal-Wallis Test

b. Grouping Variable: Group

Based on the results of the Kruskal–Wallis test, the value of H = 28.191, with degrees of freedom (df) = 7 and a significance level (Asymp. Sig.) = 0.000. Since the significance value is smaller than 0.05, it can be concluded that there are significant differences in locomotor skill scores among the eight groups of female students with intellectual disabilities.

The results of the Kruskal–Wallis test for the locomotor movement performance of male students with hearing impairments are presented in Table 27 below.

Table 27. Results of the Kruskal–Wallis test for the locomotor movement performance of male students with hearing impairments

Test Statistics[a,b]	
	Score
Kruskal-Wallis H	10.657
df	1
Asymp. Sig.	.001

a. Kruskal-Wallis Test

b. Grouping Variable: Group

The Kruskal–Wallis test shows a value of H = 10.657 with 1 degree of freedom (df) and a significance level (Asymp. Sig.) = 0.001. Since the significance value is less than 0.05, it can be concluded that there is a significant difference in locomotor skill scores between the two groups.

The results of the Kruskal–Wallis test for the locomotor movement performance of male students with hearing impairments are presented in Table 28 below.

Table 28. Results of the Kruskal–Wallis test for the locomotor movement performance of female students with hearing impairments

Test Statistics[a,b]	
	Score
Kruskal-Wallis H	10.087
df	1
Asymp. Sig.	.001

a. Kruskal-Wallis Test

b. Grouping Variable: Group

The Kruskal–Wallis test yielded H = 10.087 with 1 degree of freedom (df) and a significance level (Asymp. Sig.) = 0.001. Because the significance value is less than 0.05, it can be concluded that there is a significant difference in locomotor skill scores between the two groups.

3.8. Results of the Nine Hole Peg Test (NHPT) Data Analysis in Students with Intellectual Disabilities and Hearing Impairments

The NHPT data analysis for male students with intellectual disabilities was conducted using the Kruskal–Wallis test, and the results are presented in Table 29 below.

Table 29. Results of the Kruskal–Wallis test for the Nine Hole Peg Test (NHPT) Data Analysis of male students with intellectual disabilities

Test Statistics[a,b]	
	Score
Kruskal-Wallis H	20.812
df	7
Asymp. Sig.	.004

a. Kruskal-Wallis Test

b. Grouping Variable: Group

Based on the Levene's test results, the significance values for all methods (Based on Mean, Median, Adjusted df, and Trimmed Mean) are greater than 0.05. This indicates that the variances of the data between the two groups are homogeneous. Therefore, the assumption of homogeneity of variances is met, and parametric statistical tests can be applied to analyze the NHPT results for students with intellectual disabilities and hearing impairments.

The NHPT data analysis for female students with intellectual disabilities was conducted using the Kruskal–Wallis test, and the results are presented in Table 30 below.

Table 30. Results of the Kruskal–Wallis test for the Nine Hole Peg Test (NHPT) Data Analysis of female students with intellectual disabilities

Test Statistics[a,b]	
	Score
Kruskal-Wallis H	4.957
df	7
Asymp. Sig.	.665

a. Kruskal-Wallis Test

b. Grouping Variable: Group

Based on the Kruskal–Wallis test, the value of Asymp. Sig. = 0.665 is greater than 0.05, indicating no significant difference in scores among the eight groups. This means that the distribution of scores across groups is relatively similar, and there are no statistically significant differences between the groups.

The NHPT data analysis for male students with hearing impairments was conducted using the Kruskal–Wallis test,

and the results are presented in Table 31 below.

Table 31. Results of the Kruskal–Wallis test for the Nine Hole Peg Test (NHPT) Data Analysis of male students with Hearing Impairments

Test Statistics[a,b]	
	Score
Kruskal-Wallis H	11.438
df	1
Asymp. Sig.	.001

a. Kruskal-Wallis Test

b. Grouping Variable: Group

Based on the Kruskal–Wallis test, the obtained value of Asymp. Sig. = 0.001 is less than 0.05, indicating a significant difference between the groups. This means that there are statistically significant differences in NHPT scores between students with intellectual disabilities and those with hearing impairments.

The NHPT data analysis for female students with hearing impairments was conducted using the Anova test, and the results are presented in Table 32 below.

Table 32. Results of Anova test for the Nine Hole Peg Test (NHPT) Data Analysis of male students with Hearing Impairments

ANOVA					
Score					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	849.766	1	849.766	13.501	.002
Within Groups	944.117	15	62.941		
Total	1793.882	16			

Based on the results of the Analysis of Variance (ANOVA), the obtained significance value (Sig. = 0.002) is less than 0.05, indicating a significant difference between the groups. This means that there are statistically significant differences in NHPT scores between students with intellectual disabilities and those with hearing impairments.

4. Discussion

The initial assessment of fine and gross motor functions among students with disabilities revealed that most participants fell within the low to very low performance categories across all measures. On the Nine-Hole Peg Test (NHPT), students generally required longer times than age-normative standards for both dominant and non-dominant hands, indicating delayed manual dexterity and bimanual coordination. Similarly, the Test of Gross Motor Development–Second Edition (TGMD-2) showed low scores in the locomotor subtest, particularly in running, hopping, and jumping activities, reflecting limited strength, coordination, and neuromotor integration [19].

The Kruskal–Wallis analysis supported these descriptive findings. Significant differences in fine motor performance ($p < 0.05$) were found only among male students with intellectual and hearing impairments, while no significant differences appeared in gross motor (locomotor) abilities across groups. This pattern suggests that fine motor skills are more susceptible to variations in neurocognitive and sensory processing, whereas locomotor functions—being more fundamental and repetitive—tend to be more homogeneous. These results imply that fine motor control depends more on higher cortical integration and practice accumulation, while locomotor function relies on broader body coordination with lower cognitive demand [20-22].

Overall, these findings indicate that students with disabilities, particularly those with intellectual impairments, experience reduced manual dexterity and limited movement coordination due to insufficient sensory-motor stimulation and restricted engagement in structured physical activities. Many participants likely lacked early motor experiences or inclusion in physical education, compounded by neurological constraints. From a neuroplasticity perspective, this limited stimulation during early development hinders the formation of synaptic connections between the peripheral motor system and central motor regions, thereby restricting cortical reorganization and efficient movement learning [23].

This interpretation aligns with findings from [24, 25], which demonstrated that children with developmental motor delays or mild neurological impairments showed significant improvement in TGMD-2 and NHPT performance following structured interventions based on the FITT principle. These studies affirm that motor function in children with disabilities is not static but highly adaptable when supported by consistent, targeted training [26, 27].

The theoretical foundation of neuroplasticity provides a critical rationale for designing structured motor interventions. Neuroplasticity represents an active adaptive mechanism in which repeated, meaningful movements strengthen existing neural pathways and facilitate new synaptic formation [23]. Consequently, physical interventions extend beyond enhancing muscle strength—they activate the brain's capacity for motor relearning.

Within this framework, the FITT principle (Frequency, Intensity, Time, and Type) plays a central role in optimizing neuroplastic outcomes. Exercise with appropriate frequency and moderate intensity, typically three 50–60-minute sessions per week, stimulates progressive cortical adaptation [28, 29]. Gradual adjustments in training time and type enhance the nervous system's ability to respond to increasing motor demands [30]. Clinical studies have shown that even in children with neurological limitations, consistent and structured motor practice leads to measurable improvements in performance [20, 29, 30].

Based on the identified motor deficits (low to very low coordination, strength, and neuromotor integration) and

neuroplasticity principles, initial FITT recommendations for the Bocce game-based Problem-Based Learning module for students with intellectual disabilities can be formulated:

Frequency: Interventions should be administered regularly. Programs targeting strength, endurance, and flexibility have shown positive outcomes with 3 sessions per week [31]. Intensity: While clear practical guidelines for exercise intensity in individuals with intellectual disabilities are sometimes lacking [32], moderate-to-vigorous physical activity is generally advised for health benefits. Time: Effective intervention sessions typically range from 50 to 60 minutes [32, 33]. Studies on physical education interventions suggest that total weekly durations of 4 to 10 hours can positively impact gross motor coordination in early childhood [34]. Type: The intervention must incorporate varied and multicomponent physical activities, encompassing locomotor movements, object control, balance, and strength [16].

In the context of inclusive education in Indonesia, these results emphasize the importance of integrating motor function assessment into individualized learning strategies. Collaboration among physical education teachers, occupational therapists, and classroom educators is essential for designing data-driven, adaptive exercise programs guided by the FITT principle. This aligns with the Universal Design for Learning (UDL) framework, which promotes equitable and responsive learning environments that accommodate diverse needs [35-37].

Despite its contributions, this study has several limitations. The pretest-only design limits causal inference regarding the FITT-based intervention's potential effects. The sample size and heterogeneity of disability types restrict generalizability, and external variables such as nutrition, family support, and previous therapy were uncontrolled. Moreover, performance-based assessments like the NHPT and TGMD-2 may exhibit observer or measurement bias, particularly in heterogeneous disability populations [38].

Future research should employ experimental or longitudinal designs to track developmental trajectories and causal effects of exercise-based interventions. Long-term observation will better capture the dynamics of motor adaptation, clarify the role of contextual factors, and strengthen the evidence for neuroplastic changes in this population.

In summary, this preliminary study provides crucial baseline data on motor performance in students with disabilities, confirming substantial deficits in fine and gross motor coordination yet highlighting their neuroplastic potential. Integrating structured FITT-based interventions and continuous motor assessments within inclusive schools can enhance both motor and cognitive outcomes, promoting a more holistic and equitable educational approach.

5. Conclusions

This study highlights that students with disabilities show marked deficits in fine and gross motor coordination, yet these limitations are modifiable through neuroplastic adaptation. The findings underscore that baseline motor mapping is essential for understanding each learner's functional profile and should serve as a foundation for individualized physical interventions.

The primary implication is that baseline motor assessment must precede the design of personalized FITT-based exercise programs in inclusive schools. Integrating these data-driven approaches within the Universal Design for Learning (UDL) framework can promote equitable participation, enhance motor-cognitive outcomes, and translate neuroplasticity theory into effective educational practice. Future research should focus on validating this approach through longitudinal intervention models.

Acknowledgements

This research was supported by funding from the Directorate General of Research and Development, Ministry of Higher Education, Science, and Technology, under contract number 035/LL6/PL/AL.04/2025. The authors gratefully acknowledge this support.

REFERENCES

[1] W. C. Su, N. Amonkar, C. Cleffi, S. Srinivasan, and A. Bhat, "Neural Effects of Physical Activity and Movement Interventions in Individuals With Developmental Disabilities–A Systematic Review," *Front. Psychiatry*, vol. 13, 2022, doi: 10.3389/fpsyt.2022.794652.

[2] A. R. Tsuchida and E. E. Centeio, "P.L.A.Y. for All Pilot: Effects of a Community-Based, Inclusive After-School Program on Physical Activity and Motor-Skill Outcomes," *International Journal of Physical Activity and Health*, vol. 4, no. 3, 2025, doi: 10.18122/ijpah.4.3.2.boisestate.

[3] T. Piotrowski *et al.*, "Fundamental Movement / Motor Skills as an Important Component of Physical Literacy and Bridge to Physical Activity: A Scoping Review," *Children*, vol. 12, no. 10, p. 1406, 2025, doi: 10.3390/children12101406.

[4] J. Gao, "Motor-Based Interventions in Children with Developmental Coordination Disorder: A Systematic Review and Meta-analysis of Randomised Controlled Trials," *Sports Med Open*, vol. 11, no. 1, p. 59, 2025. doi: 10.1186/s40798-025-00833-w.

[5] M. Alesi, V. Giustino, A. Gentile, M. Gómez-López, and G. Battaglia, "Motor Coordination and Global Development in Subjects with Down Syndrome: The Influence of Physical Activity," *J. Clin. Med.*, vol. 11, no. 17, p. 5031, 2022, doi: 10.3390/jcm11175031.

[6] A. Carballo-Fazanes, E. Rey, N. C. Valentini, C. Varela-Casal, and C. Abelairas-Gómez, “Interrater Reliability of the Test of Gross Motor Development-Third Edition Following Raters’ Agreement on Measurement Criteria,” *J. Mot. Learn. Dev.*, vol. 11, no. 2, pp. 225–244, 2023, doi: 10.1123/jmld.2022-0068.

[7] E. Diril, B. Menek, A. Emir, D. Tarakci, and E. Tarakci, “The Effect of a Video-Based Game Exercise Program on Motor Skills, Proprioception, and Cognitive Functions in Individuals With Intellectual Disabilities,” *Occup. Ther. Int.*, vol. 2025, no. 1, p. 8410494, 2025, doi: 10.1155/oti/8410494.

[8] A. J. Hilderley, F. V. Wright, M. J. Taylor, J. L. Chen, and D. Fehlings, “Functional Neuroplasticity and Motor Skill Change Following Gross Motor Interventions for Children With Diplegic Cerebral Palsy,” *Neurorehabil. Neural Repair*, vol. 37, no. 1, pp. 16–26, 2023, doi: 10.1177/15459683221143503.

[9] J. Kumar *et al.*, “Innovative Approaches and Therapies to Enhance Neuroplasticity and Promote Recovery in Patients with Neurological Disorders: A Narrative Review,” *Cureus*, vol. 15, no. 7, p. e41914, 2023, doi: 10.7759/cureus.41914.

[10] A. Ungureanu, L. Rusu, M. R. Rusu, and M. I. Marin, “Balance Rehabilitation Approach by Bobath and Vojta Methods in Cerebral Palsy: A Pilot Study,” *Children*, vol. 9, no. 10, p. 1481, 2022, doi: 10.3390/children9101481.

[11] J. R. Lemos, “Respiratory muscle training in non-athletes and athletes with spinal cord injury: A systematic review of the effects on pulmonary function, respiratory muscle strength and endurance, and cardiorespiratory fitness based on the FITT principle of exercise prescription,” *J. Back Musculoskelet. Rehabil.*, vol. 33, no. 4, pp. 655–667, 2020, doi: 10.3233/BMR-181452.

[12] Y. Purwasih, “The Effect of Gobak Sodor and Engklek Games on Rude Motor Development and Cognitive Improvement in Class 4 Children SDN Pojok 1 Kediri,” *J. Res. Public Heal.*, vol. 2, no. 1, 2020, [Online]. Available: https://www.jrph.org/index.php/JRPH/article/view/30

[13] A. Hodges, R. Cordier, A. Joosten, H. Bourke-Taylor, and Y. W. Chen, “Evaluating the feasibility, fidelity, and preliminary effectiveness of a school-based intervention to improve the school participation and feelings of connectedness of elementary school students on the autism spectrum,” *PLoS One*, vol. 17, no. 6, p. e0269098, 2022, doi: 10.1371/journal.pone.0269098.

[14] D. Zhang, K. G. Soh, Y. M. Chan, X. Feng, M. Bashir, and W. Xiao, “Effect of functional training on fundamental motor skills among children: A systematic review,” *Heliyon*, vol. 10, no. 23, p. e39531, 2024, doi: 10.1016/j.heliyon.2024.e39531.

[15] S. Campbell *et al.*, “Purposive sampling: complex or simple? Research case examples,” *J. Res. Nurs.*, vol. 25, no. 8, pp. 652–661, 2020, doi: 10.1177/1744987120927206.

[16] H. Kavanagh, M. Manninen, and J. Issartel, “Comparing the fundamental movement skill proficiency of children with intellectual disabilities and typically developing children: a systematic review and meta-analysis,” *J. Intellect. Disabil. Res.*, vol. 67, no. 12, pp. 1336–1353, 2023, doi: 10.1111/jir.13012.

[17] G. Moreno-Morente, M. Hurtado-Pomares, A. Sánchez-Pérez, and M. C. Terol-Cantero, “Translation, Cross-Cultural Adaptation, and Feasibility of the NHPT-E of Manual Dexterity for the Spanish Population,” *Healthc.*, vol. 12, no. 5, p. 550, 2024, doi: 10.3390/healthcare12050550.

[18] F. Temporiti *et al.*, “Kinematic evaluation and reliability assessment of the Nine Hole Peg Test for manual dexterity,” *J. Hand Ther.*, vol. 36, no. 3, pp. 560–567, 2023, doi: 10.1016/j.jht.2022.01.007.

[19] M. A. O. Rosales, J. T. Fonseca, M. A. C. Araya, and J. Moncada-Jiménez, “Effect of Exercise in Aquatic Environments on Physical Fitness in People with Intellectual Disabilities: A Systematic Review,” *MHSalud*, vol. 20, no. 1, 2023, doi: 10.15359/mhs.20-1.7.

[20] V. Vacchini *et al.*, “Improving neuroplasticity and Quality of Life in children with Cerebral Palsy: a customized intensive motor training protocol integrating the HABIT-ILE approach,” *Front. Rehabil. Sci.*, vol. 6, pp. 1–8, 2025, doi: 10.3389/fresc.2025.1613103.

[21] M. Siddiqui, S. I. Farooqui, J. Rizvi, B. A. Soomro, and B. Hassan, “Improving Motor Proficiency in Children with Developmental Delays: A Meta-Analysis Evaluating the Impact of Motor Skills Interventions,” *J. Intellect. Disabil. - Diagnosis Treat.*, vol. 11, no. 5, pp. 226–235, 2024, doi: 10.6000/2292-2598.2023.11.05.2.

[22] A. Kushnir and O. Kachmar, “Intensive Neurophysiological Rehabilitation System for children with cerebral palsy: a quasi-randomized controlled trial,” *BMC Neurol.*, vol. 23, no. 1, p. 157, 2023, doi: 10.1186/s12883-023-03216-4.

[23] J. P. Ferreira, R. Matos, M. J. Campos, D. Monteiro, R. Antunes, and M. Jacinto, “Effects of Physical Exercise Program in Adults with Intellectual and Developmental Disabilities—A Study Protocol,” *J. Clin. Med.*, vol. 11, no. 24, p. 7485, 2022, doi: 10.3390/jcm11247485.

[24] P. J. Hsu, H. L. Yeh, C. L. Tsai, C. H. Chu, F. C. Chen, and C. Y. Pan, “Effects of a floor hockey intervention on motor proficiency, physical fitness, and adaptive development in youths with mild intellectual disabilities,” *Int. J. Environ. Res. Public Health*, vol. 18, no. 13, p. 7059, 2021, doi: 10.3390/ijerph18137059.

[25] K. Lee, “Enhancing Motor Performance and Physical Fitness in Children with Developmental Coordination Disorder Through Fundamental Motor Skills Exercise,” *Healthc.*, vol. 12, no. 21, p. 2142, 2024, doi: 10.3390/healthcare12212142.

[26] M. I. N. Wibisana and I. F. Royana, “A Randomized Controlled Trial on the Effectiveness of FITT Principle In Increasing VO2 Max,” *Musamus J. Phys. Educ. Sport Musamus J. Phys. Educ. Sport*, vol. 6, no. 1, pp. 333–342, 2023, doi: 10.35724/mjpes.v6i1.5786.

[27] G. Strofylla, S. Charitou, K. Asonitou, and D. Koutsouki, “Efficacy of 6-Month Adapted Aerobic Program on Motor Proficiency, BMI and Cognitive Abilities of Students with Autism Spectrum Disorder: Three Case Reports,” *Open J. Soc. Sci.*, vol. 09, no. 09, pp. 153–166, 2021, doi: 10.4236/jss.2021.99011.

[28] J. Dołęga *et al.*, “Neuroplasticity. How regular physical activity influences the brain’s structure and function,” *Qual. Sport*, vol. 34, p. 56026, 2024, doi: 10.12775/qs.2024.34.56026.

[29] A. Busquets, B. Ferrer-Uris, T. Durduran, F. Bešlija, M. Añón-Hidalgo, and R. Angulo-Barroso, "Study protocol to examine the effects of acute exercise on motor learning and brain activity in children with developmental coordination disorder (ExLe-Brain-DCD)," *PLoS One*, vol. 19, no. 5 p. e0302242, 2024, doi: 10.1371/journal.pone.0302242.

[30] Z. Yan, P. Yan, C. Qin, and J. Luo, "Review on the Formulation, Existing Problems, and Practical Effects of Fitness Exercise Prescriptions for People With Intellectual Disabilities," *Front. Public Heal.*, vol. 10, pp. 1–10, 2022, doi: 10.3389/fpubh.2022.936830.

[31] H. Babagoltabar-Samakoush, B. Aminikhah, and S. Bahiraei, "Effectiveness of dynamic neuromuscular stabilization training on strength, endurance, and flexibility in adults with intellectual disabilities, a randomized controlled trial," *Sci. Rep.*, vol. 15, no. 1, pp. 1–15, 2025, doi: 10.1038/s41598-024-85046-z.

[32] M. I. N. Wibisana and I. F. Royana, "A Randomized Controlled Trial on the Effectiveness of FITT Principle In Increasing VO2 Max," *Musamus J. Phys. Educ. Sport Musamus J. Phys. Educ. Sport*, vol. 6, no. 1, pp. 333–342, 2023, doi: 10.35724/mjpes.v6i1.6023.

[33] Y. Ye, K. Ning, B. Wan, and C. Shangguan, "The Effects of the Exercise Intervention on Fundamental Movement Skills in Children with Attention Deficit Hyperactivity Disorder and/or Autism Spectrum Disorder: A Meta-Analysis," *Sustain.*, vol. 15, no. 6, p. 5206, 2023, doi: 10.3390/su15065206.

[34] G. A. Navarra *et al.*, "How Does the Amount of a Physical Education Intervention Affect Gross Motor Coordination in Early Childhood?," *J. Funct. Morphol. Kinesiol.*, vol. 7, no. 4, 2022, doi: 10.3390/jfmk7040096.

[35] T. Sapre *et al.*, "Enhancing home-based physical activity for neurodivergent children: adapting the InPACT at Home program with AI and universal design," *Front. Physiol.*, vol. 15, pp. 1–14, 2024, doi: 10.3389/fphys.2024.1496114.

[36] C. Lourenço, O. Ben Rakaa, M. Bassiri, and S. Lotfi, "Unravelling the Impact of Universal Design for Learning on the Inclusion of Students with Disabilities in Physical Education: A Systematic Review," *Phys. Educ. Theory Methodol.*, vol. 25, no. 3, pp. 691–704, 2025, doi: 10.17309/tmfv.2025.3.27.

[37] H. L. Brossman, L. A. Chiarello, R. J. Palisano, and K. D. Wynarczuk, "A Collaborative Approach to Support Participation in Physical Recreation for Preschool Students with Multiple Disabilities: A Case Series," *Disabilities*, vol. 3, no. 4, pp. 591–607, 2023, doi: 10.3390/disabilities3040038.

[38] B. Smits-Engelsman, E. Verbecque, M. Denysschen, and D. Coetzee, "Exploring Cultural Bias in Two Different Motor Competence Test Batteries When Used in African Children," *Int. J. Environ. Res. Public Health*, vol. 19, no. 11, p. 6788, 2022, doi: 10.3390/ijerph19116788.