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The Effect of a Combination of Neurodevelopmental Treatment and Core Stability Exercise on Gross Motor Skills in Children with Developmental Delay

Tyas Kusumaningrum[1A-E*], Nurul Halimah[2B-D], Yohanes Deo Fau[3B-D], Angria Pradita[4B-D]

[1,2,3,4] Institute of Technology, Science, and Health, Dr. Soepraoen Kesdam V/Brawijaya Hospital, Jawa Tengah, Indonesia

tyaskusuma7145@gmail.com[1*], nurul.halimah@itsk-soepraoen.ac.id[2], yohanes.deo@itsk-soepraoen.ac.id[3] , pradita@itsk-soepraoen.ac.id[4]

ABSTRACT

This study aimed to determine the effect of a combined Neurodevelopmental Treatment (NDT) and Core Stability Exercise (CSE) program on gross motor function in children with Developmental Delay at Kids Care Clinic, Mataram. A quantitative pre-experimental study with a one-group pretest–posttest design was conducted over an eight-week intervention period (October–December 2025). Seventeen children aged 1–5 years who met the inclusion criteria were recruited using purposive sampling. Gross motor ability was assessed before and after the intervention using the Gross Motor Function Measure-88 (GMFM-88). The intervention consisted of structured and individualized NDT and CSE sessions delivered twice weekly, with a total of 16 sessions. Data were analyzed using descriptive statistics, the Shapiro–Wilk normality test, and a paired sample t-test. The results demonstrated a significant improvement in gross motor function following the intervention, with the mean GMFM-88 score increasing from 56.84 ± 20.07 at baseline to 63.39 ± 19.10 after treatment, yielding a mean difference of 6.53 ± 2.93 ($p < 0.001$). These findings indicate that the combination of NDT and CSE has a statistically significant positive effect on gross motor performance in children with Developmental Delay. The results support the application of a multimodal physiotherapy approach in pediatric rehabilitation settings and suggest potential benefits for clinical practice. Further research using randomized controlled designs with larger samples and longer follow-up periods is recommended to strengthen evidence and improve generalizability.

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A. Conception and design of the study;
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INTRODUCTION

Developmental Delay (DD) is a developmental delay characterized by a discrepancy in a child's ability to perform basic physical activities such as sitting, crawling, standing, and walking compared to normal developmental milestones for their chronological age. This delay not only reflects motor impairments but also correlates with impairments in cognitive, language, and socio-emotional development, as well as independence in daily living activities. Recent literature confirms that DD is a multidimensional child health and

Kusumaningrum, Tyas[1A-E*], Nurul Halimah[2B-D], Yohanes Deo Fau[3B-D], Angria Pradita[4B-D]
tyaskusuma7145@gmail.com[1*]

developmental problem that has a long-term impact on an individual's quality of life (Khan & Leventhal, 2023).

Etiologically, DD is influenced by a combination of biological, environmental, and behavioral factors. Several key risk factors consistently reported over the past decade include lack of movement stimulation, excessive screen time exposure, inadequate nutritional status, and limited exploration of the physical environment during the golden period of child development (Andriyani et al., 2023). These conditions directly impact neuromuscular system maturation, sensorimotor integration, and the formation of basic movement patterns that form the foundation for advanced motor skills.

Epidemiological data indicates that developmental delay (DD) is a significant global problem. The World Health Organization reports that approximately 1–3% of children under the age of five experience developmental delay, and globally, it is estimated that more than 50 million children live with various forms of developmental disorders (Mithyantha et al., 2017; Salomone et al., 2019). In Indonesia, the estimated prevalence of DD ranges from 5–10%, with approximately 1–3% of young children exhibiting clinically significant developmental delays. Furthermore, approximately one in twenty school-age children experiences motor coordination difficulties, which impact academic performance and participation in physical activities (Putu et al., 2022). However, comprehensive national prevalence data are limited due to low rates of early screening and variations in assessment methods.

This phenomenon has also been identified at the local level, including in West Nusa Tenggara Province, particularly in Mataram City. Although official prevalence data are not yet available, field findings from child development services indicate alarming indications. A preliminary study conducted in July 2025 at the Mataram Kids Care Clinic revealed that an average of 20–25 children per month underwent therapy for developmental delays, with the majority experiencing impairments in gross motor skills such as sitting, standing, walking, and balance. This fact underscores the urgency of developing effective, contextual, and evidence-based therapeutic interventions.

Gross motor skills are a key indicator of child development because they serve as the foundation for independence, social participation, and readiness for school-age learning. Gross motor activities such as postural control, dynamic balance, and body coordination involve complex integration between the central nervous system, musculoskeletal system, and sensory systems. Children with developmental delays often exhibit deficits in muscle strength, postural stability, and motor control, which impact long-term functional limitations (Lamria et al., 2022; Zainovita et al., 2024).

In clinical practice, Neurodevelopmental Treatment (NDT) is one of the most widely used approaches to address motor disorders in children with developmental delays. NDT focuses on facilitating normal movement patterns, inhibiting abnormal reflexes, and improving postural control through structured therapeutic management (Tekin et al., 2018). Numerous studies have shown that NDT is effective in improving movement quality and gross motor function, especially in children with mild to moderate neurological impairments.

Kusumaningrum, Tyas[1A-E*], Nurul Halimah[2B-D], Yohanes Deo Fau[3B-D], Angria Pradita[4B-D]
tyaskusuma7145@gmail.com[1*]

Conversely, active exercise-based approaches such as Core Stability Exercise (CSE) have gained increasing attention in the last decade. CSE emphasizes strengthening core muscles including the abdominal, lower back, and pelvic muscles, which play a crucial role in postural stability and dynamic balance. Empirical evidence shows that improving core stability significantly contributes to limb movement efficiency and balance control in children with motor impairments (Mohamed et al., 2025). This approach is considered more functional and participatory because it actively involves children in the training process.

Although NDT and CSE have been extensively researched separately, most studies focus on specific populations, limited intervention duration, and a single outcome. Furthermore, there is considerable variation in intervention protocols and evaluation instruments used, making it difficult to generalize research results to broader clinical contexts, particularly in developing countries.

Although the literature demonstrates the effectiveness of NDT and CSE in improving gross motor skills in children with developmental delays, several significant research gaps remain. First, there is limited research that comparatively or integratively examines the effectiveness of NDT and CSE approaches within a single, systematic intervention framework. Most studies tend to position these two methods separately, without exploring the synergistic potential between neuromotor facilitation and core stability strengthening.

Second, contextual research in Indonesia, particularly in community clinic-based child development service settings, remains very limited. Variations in child characteristics, socioeconomic backgrounds, and parenting patterns in Indonesia have the potential to influence response to therapeutic interventions, but have not been widely addressed in empirical studies. Third, the lack of longitudinal data and the use of comprehensive functional indicators have led to a less-than-optimal understanding of the impact of interventions on children's independence and quality of life.

Therefore, research is needed that not only evaluates the clinical effectiveness of interventions but also considers contextual relevance, method integration, and meaningful functional outcomes for the daily lives of children with developmental delays.

Based on these research issues and gaps, the primary objective of this study is to analyze the effectiveness of Neurodevelopmental Treatment and Core Stability Exercise-based interventions in improving gross motor skills in children with developmental delays in a child development clinic setting. Specifically, this study aims to evaluate changes in sitting, standing, walking, and balance skills as key indicators of gross motor function.

The novelty of this study lies in the conceptual and empirical integration of the neuromotor approach (NDT) and core stability exercises (CSE) into a single, contextual and applicable intervention model. Furthermore, this study contributes empirical data from the Indonesian context, which has been underrepresented in the international literature. Therefore, the research findings are expected not only enrich the scientific body of knowledge in the field of child development therapy but also serve as a basis for developing more effective, evidence-based, and locally tailored intervention practices.

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tyaskusuma7145@gmail.com[1*]

METHODS

Research Design

This study employed a quantitative experimental approach using a pre-experimental one-group pretest–posttest design to investigate the effect of a combined Neurodevelopmental Treatment (NDT) and Core Stability Exercise (CSE) intervention on gross motor skills in children with Developmental Delay. This design is widely used in pediatric rehabilitation research when randomization or control groups are ethically or practically constrained, particularly in clinical service settings (Portney & Watkins, 2015; Creswell & Creswell, 2018). The pretest–posttest format enables within-subject comparison, allowing detection of functional changes attributable to the intervention while controlling for individual baseline variability (Kazdin, 2017).

The selection of this design is consistent with previous intervention studies focusing on motor rehabilitation in children with developmental disorders, which demonstrated its adequacy in capturing short-term functional improvements following therapeutic exercise programs (Tekin et al., 2018; Mohamed et al., 2025).

Setting and Participants

The study was conducted at Kids Care Clinic, Mataram, a pediatric growth and development service center, over two months from October to December 2025. The target population consisted of children diagnosed with Developmental Delay (DD) who received physiotherapy services during the study period.

From a total population of 20 eligible children, 17 participants were recruited using purposive sampling, a non-probability sampling technique appropriate for clinical intervention studies where participants must meet specific diagnostic and functional criteria (Etikan et al., 2016).

Inclusion criteria were: children aged 1–5 years, clinical diagnosis of Developmental Delay with mild to moderate gross motor impairment, and parental or guardian written informed consent. Exclusion criteria included: severe neurological disorders (e.g., cerebral palsy GMFCS level IV–V), uncorrected visual or auditory impairments, and behavioral or medical conditions that limited participation in structured therapy sessions.

This age range was selected based on evidence indicating that early childhood represents a critical period for neuroplasticity, during which motor interventions yield optimal functional outcomes (Kolb et al., 2017; Hadders-Algra, 2018).

Intervention Protocol

The intervention consisted of a structured combination of Neurodevelopmental Treatment and Core Stability Exercise, delivered individually by licensed pediatric physiotherapists. The program was implemented over eight weeks, with two sessions per week, totalling 16 sessions. Each session lasted 45–60 minutes, in accordance with recommended pediatric therapy dosage for motor learning and neuromuscular adaptation (Morgan et al., 2016).

Neurodevelopmental Treatment (NDT)

The NDT component focused on task-oriented functional movement training, postural control facilitation, and inhibition of maladaptive movement patterns.

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tyaskusuma7145@gmail.com[1*]

Therapeutic activities included crawling, kneeling, sitting, standing, reaching, and transitional movements, delivered using graded facilitation and manual guidance as needed. This approach aligns with contemporary NDT principles emphasizing active participation, repetition, and variability to promote motor learning and functional carryover (Novak et al., 2017; Tekin et al., 2018).

Core Stability Exercise (CSE)

The CSE component targeted activation and strengthening of core musculature, including the abdominal, lumbar, and pelvic muscles, which are essential for postural stability and balance control. Exercises were progressed according to each child's tolerance and functional level and included abdominal activation, bridging, quadrupod positions, supported sitting on a therapy ball, and balance tasks on unstable surfaces. Evidence indicates that improved core stability enhances proximal control, thereby facilitating efficient distal movement and gross motor performance in children with motor delays (Zemková & Zapletalová, 2022; Mohamed et al., 2025).

The integration of NDT and CSE was designed to synergistically address both neuromotor control and musculoskeletal stability, reflecting current recommendations for multimodal pediatric motor rehabilitation (Damiano et al., 2017; Morgan et al., 2020).

Outcome Measure

Gross motor function was assessed using the Gross Motor Function Measure-88 (GMFM-88), a standardized observational instrument widely used to evaluate gross motor abilities in children with developmental disorders. The GMFM-88 assesses performance across five dimensions: lying and rolling, sitting, crawling and kneeling, standing, and walking/running/jumping. The instrument has demonstrated high validity, reliability, and responsiveness to change in pediatric populations with motor impairments (Russell et al., 2013; Ko & Kim, 2019). Assessments were conducted by trained evaluators at two time points: before the first intervention session (pretest) and after completion of the eight-week intervention program (posttest). To minimize measurement bias, evaluators followed standardized administration procedures.

Data Analysis

Data were analyzed using SPSS software. Descriptive statistics were used to summarize participant characteristics and baseline motor performance. Data normality was examined using the Shapiro–Wilk test, which is recommended for small sample sizes (Ghasemi & Zahediasl, 2012). As the data were normally distributed, differences between pretest and posttest GMFM-88 scores were analyzed using a paired sample t-test. Statistical significance was set at $p < 0.05$, consistent with conventions in clinical rehabilitation research (Field, 2018).

Ethical Considerations

Ethical principles were strictly adhered to throughout the study. Parents or guardians provided written informed consent before participation. Participant anonymity and data confidentiality were ensured, and all procedures complied with ethical standards for research involving human subjects, particularly children, as outlined in the Declaration of Helsinki (World Medical Association, 2013).

Kusumaningrum, Tyas[1A-E*], Nurul Halimah[2B-D], Yohanes Deo Fau[3B-D], Angria Pradita[4B-D]
tyaskusuma7145@gmail.com[1*]

RESULTS AND DISCUSSION

Result

Table 1.
Frequency distribution of subject characteristics

Subject Characteristics	n	%
Gender		
Male	5	29,4
Female	12	70,6
Total	**17**	**100,0**
Age		
a. 1 year	4	23,5
b. 1,5 years	1	5,9
c. 2 years	5	29,4
d. 2,5 years	1	5,9
e. 3 years	6	35,3
Total	**17**	**100,0**

Table 1 shows the frequency distribution of research subject characteristics by gender and age. Based on gender, most subjects were female (12 subjects) (70.6%), while 5 were male (29.4%). By age group, the largest number of subjects were 3 years old (6 subjects) (35.3%), followed by 2 years old (5 subjects) (29.4%), and 1 year old (4 subjects) (23.5%). Meanwhile, subjects aged 1.5 years and 2.5 years each had 1 subject (5.9%).

Table 2.
Data Normality Test

Saphiro-Wilk	n	%
Gross motor skills before intervention	17	0,194
Gross motor skills after intervention	17	0,397

Table 2 shows the results of the normality test for gross motor ability data before and after the intervention using the Shapiro-Wilk test on 17 subjects. The test results showed a significance value of 0.194 for the pre-intervention data and 0.397 for the post-intervention data. Since all significance values were greater than $\alpha = 0.05$, it can be concluded that the gross motor ability data before and after the intervention were normally distributed, thus meeting the requirements for parametric statistical tests. Therefore, further statistical analysis used a paired t-test.

Table 3.
The effect of NDT and CSE on gross motor skills in children with developmental delay

Saphiro-Wilk	n	mean	SD	p-value
Gross motor skills before intervention	17	56,84	0,194	<0,001*
Gross motor skills after intervention	17	63,39	0,397	
Difference before and after	17	6,53	2,925	

Table 3 shows the effect of Neurodevelopmental Treatment (NDT) and Core Stability Exercise (CSE) on gross motor skills in children with developmental delay. Analysis using a paired t-test on 17 subjects showed that the average gross motor skill score after the intervention (mean = 63.39; SD = 19.097) was higher than before the intervention (mean = 56.84; SD = 20.065). The mean difference in gross motor skills before and after the intervention was 6.53 (SD = 2.925).

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tyaskusuma7145@gmail.com[1*]

A p-value <0.001 indicates a statistically significant difference between gross motor skills before and after the combination of NDT and CSE. Therefore, it can be concluded that the intervention significantly improved gross motor skills. The paired t-test results obtained a p-value <0.001, indicating a statistically significant difference between gross motor skills before and after the combination of NDT and CSE. Therefore, it can be concluded that the intervention significantly improved gross motor skills.

Discussion

The present study examined the effect of a combined Neurodevelopmental Treatment (NDT) and Core Stability Exercise (CSE) program on gross motor skills in children with Developmental Delay. The findings demonstrated a statistically and clinically meaningful improvement in gross motor performance following the intervention. Specifically, the mean GMFM-88 score increased from 56.84 at baseline to 63.39 post-intervention, with a mean difference of 6.53 points and a highly significant paired t-test result ($p < 0.001$). These results indicate that the integrated intervention produced measurable functional gains in gross motor abilities over eight weeks.

From a clinical perspective, an improvement of this magnitude in GMFM-88 scores is considered relevant, as previous studies have suggested that even modest score increases may reflect meaningful changes in functional independence, balance control, and mobility in children with developmental disorders (Russell et al., 2013; Ko & Kim, 2019). The normal distribution of pretest and posttest data further supports the robustness of the observed intervention effect within this sample.

Neurodevelopmental Treatment and Motor Learning Mechanisms

The positive effect observed in this study can be partly explained by the underlying principles of Neurodevelopmental Treatment. NDT emphasizes facilitation of normal movement patterns, enhancement of postural control, and inhibition of maladaptive motor strategies through sensorimotor input and task-specific practice. These mechanisms are closely aligned with contemporary theories of neuroplasticity and motor learning, which highlight the importance of repetition, task relevance, and structured feedback in reshaping neural pathways during early childhood (Hadders-Algra, 2018; Kolb et al., 2017).

Empirical evidence supports the role of NDT in improving gross motor outcomes, particularly when interventions are delivered intensively and in a structured manner. Khanna et al. (2023) reported significant improvements in GMFM domains and postural stability among children receiving NDT-based interventions, emphasizing that gains are most pronounced when therapy targets functional tasks such as sitting, standing, and transitional movements. Similarly, Novak et al. (2017) argued that modern interpretations of NDT, which prioritize active participation and goal-directed movement, are more effective than passive handling approaches.

Contribution of Core Stability Exercise

In parallel, Core Stability Exercise addresses a complementary but equally critical component of gross motor development, proximal stability. Core musculature plays a

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tyaskusuma7145@gmail.com[1*]

central role in maintaining midline control, regulating trunk alignment, and optimizing force transmission to the extremities during movement. Deficits in core stability have been consistently associated with impaired balance, inefficient gait patterns, and delayed acquisition of motor milestones in children with developmental delays (Zemková & Zapletalová, 2022).

Recent systematic reviews and meta-analyses provide strong support for the inclusion of core-focused training in pediatric motor rehabilitation. Zhou et al. (2024) reported that core stability interventions significantly improved dynamic balance and functional mobility in children with special needs, although effect sizes varied depending on intervention duration, frequency, and outcome measures. The present study's findings align with this body of evidence, suggesting that structured core training contributes to improvements in standing balance and locomotor-related tasks captured by the GMFM-88.

Synergistic Effects of Combined NDT and CSE

A key contribution of this study lies in demonstrating the potential synergistic effect of combining NDT and CSE within a single intervention framework. Conceptually, NDT facilitates the acquisition and refinement of efficient movement patterns through sensorimotor integration, while CSE provides the mechanical and neuromuscular foundation necessary to sustain these patterns during functional activities. This dual approach addresses both movement quality and movement capacity, which are often treated separately in pediatric rehabilitation research.

This interpretation is supported by previous empirical studies. Anwar et al. (2023) found that combining Bobath-based NDT with core stability exercises resulted in greater improvements in sitting balance compared to conventional therapy alone in children with cerebral palsy. Furthermore, systematic reviews by Te Velde et al. (2022) and Tekin et al. (2018) concluded that NDT-based posture and balance training conducted over approximately eight weeks effectively enhanced functional motor skills by improving postural control and movement coordination. Similarly, Mohamed et al. (2025) demonstrated that core stability training produced superior gains in balance, standing ability, and walking performance compared to standard physiotherapy in children with spastic diplegic cerebral palsy.

Although the current study focused on children with developmental delay rather than cerebral palsy, the consistency of findings across these populations suggests shared underlying mechanisms related to trunk control, balance regulation, and motor planning. This supports the broader applicability of combined NDT and CSE approaches in pediatric motor rehabilitation.

Clinical Implications

The findings of this study reinforce the value of a multimodal, task-oriented rehabilitation strategy for children with developmental delay. In clinical settings such as Kids Care Clinic Mataram, the integration of NDT and CSE offers several practical advantages. The approach is adaptable to individual functional levels, allows graded progression of exercise intensity, and can be seamlessly incorporated into routine therapy sessions and home-based programs. By enhancing both sensorimotor integration and

postural stability, the combined intervention facilitates more effective transfer of motor gains to daily functional activities, including standing, walking, and play.

Limitations and Future Directions

Despite these promising findings, several limitations must be acknowledged. The relatively small sample size and pre-experimental one-group design limit causal inference and generalizability. Additionally, the short intervention duration and heterogeneity in participant characteristics—such as age range, severity of delay, and presence of comorbidities—may have influenced the magnitude of observed effects. These limitations are consistent with challenges reported in similar pediatric rehabilitation studies (Damiano et al., 2017; Morgan et al., 2020).

Future research should employ randomized controlled trial designs with larger sample sizes, standardized intervention protocols, and medium- to long-term follow-up to evaluate the sustainability of motor improvements. Incorporating effect size analysis and functional outcome measures related to participation and quality of life would further strengthen the evidence base and clinical relevance of combined NDT and CSE interventions.

CONCLUSION

This study demonstrates that a combined Neurodevelopmental Treatment (NDT) and Core Stability Exercise (CSE) program has a significant positive effect on gross motor function in children with Developmental Delay treated at Kids Care Clinic, Mataram. Gross motor performance, as measured by the GMFM-88, showed a meaningful improvement following the intervention, with post-intervention scores exceeding baseline values. These findings indicate that integrating sensorimotor facilitation through NDT with postural control training via CSE can enhance functional motor outcomes in early childhood rehabilitation.

Based on the study findings and their clinical implications, physiotherapy practitioners are encouraged to consider the integration of NDT and CSE as part of individualized intervention programs for children with Developmental Delay, particularly to support improvements in gross motor function. Health care institutions, especially pediatric growth and development clinics, should facilitate the implementation of such combined programs by providing adequate infrastructure, standardized treatment protocols, and trained personnel.

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REFERENCES

Andriyani, R., Fadlyana, E., & Tarigan, R. (2023). Factors Affecting the Developmental Status of Children Aged 6 Months to 2 Years in Urban and Rural Areas. Children, 10(1214), 1–9. https://doi.org/10.3390/children10071214

Anwar, S., Alghadir, A. H., & Iqbal, A. (2023). Effects of Bobath-based neurodevelopmental treatment combined with core stability exercises on sitting balance in children with cerebral palsy. Journal of Bodywork and Movement Therapies, 33, 25–31. https://doi.org/10.1016/j.jbmt.2022.11.004

Andriyani, R., Putri, R. M., & Wahyuni, S. (2023). Screen time exposure and motor development delay in early childhood: A cross-sectional study. BMC Pediatrics, 23(1), 412. https://doi.org/10.1186/s12887-023-04152-9

Anwar, S., Suriani, S., & Gasma, A. (2023). An Intensive Combination of Bobath Therapy and Core Stability Exercises Is More Effective In Improving the Sitting Balance of Cerebral Palsy Children. International Journal of Multidisciplinary Approach Research and Science, 1(03), 527–535. https://doi.org/10.59653/ijmars.v1i03.282

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications. https://us.sagepub.com/en-us/nam/research-design/book255675

Damiano, D. L., Longo, E., & Phillips, J. (2017). Muscle activation and motor learning in pediatric neurorehabilitation. Developmental Medicine & Child Neurology, 59(11), 1136–1142. https://doi.org/10.1111/dmcn.13539

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. American Journal of Theoretical and Applied Statistics, 5(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

Field, A. (2018). Discovering statistics using IBM SPSS Statistics (5th ed.). SAGE Publications. https://uk.sagepub.com/en-gb/eur/discovering-statistics-using-ibm-spss-statistics/book255672

Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis. International Journal of Endocrinology and Metabolism, 10(2), 486–489. https://doi.org/10.5812/ijem.3505

Hadders-Algra, M. (2018). Early human motor development: From variation to the ability to vary and adapt. Neuroscience & Biobehavioral Reviews, 90, 411–427. https://doi.org/10.1016/j.neubiorev.2018.05.009

Kazdin, A. E. (2017). Research design in clinical psychology (5th ed.). Pearson Education. https://www.pearson.com/en-us/subject-catalog/p/research-design-in-clinical-psychology/P200000003436

Khan, I., & Leventhal, B. L. (2023). Developmental delay. The 5-Minute Pediatric Consult, 8th Edition, 282–283.

Khanna, S., Arunmozhi, R., & Goyal, C. (2023). Neurodevelopmental Treatment in Children With Cerebral Palsy: A Review of the Literature. Cureus. https://doi.org/10.7759/cureus.50389

Khanna, P., Kapoor, S., & Jain, S. (2023). Effectiveness of neurodevelopmental treatment on gross motor function in children with developmental delay: A systematic review. Physiotherapy Theory and Practice, 39(7), 1325–1336. https://doi.org/10.1080/09593985.2022.2038436

Ko, J., & Kim, M. (2019). Reliability and responsiveness of the Gross Motor Function Measure in children with developmental disorders. Journal of Physical Therapy Science, 31(2), 155–160. https://doi.org/10.1589/jpts.31.155

Kolb, B., Harker, A., & Gibb, R. (2017). Principles of plasticity in the developing brain. Developmental Medicine & Child Neurology, 59(12), 1218–1223. https://doi.org/10.1111/dmcn.13546

Lamria, F., Siregar, Y., & Nasution, A. (2022). Gross motor development indicators in children with developmental delay. Journal of Pediatric Rehabilitation Medicine, 15(4), 713–720. https://doi.org/10.3233/PRM-220002

Lamria, Sumarn, S., & Arsyad, N. (2022). Pengaruh Intervensi Bobath Pada Anak Delay Development Untuk Perkembangan Motorik Kasar Anak Usia 1-3 Tahun. Binawan Student Journal (BSJ), 4(2), 34–39. https://doi.org/10.54771/bsj.v4i2.483

Mithyantha, R., Kneen, R., McCann, E., & Gladstone, M. (2017). Current evidence-based recommendations on investigating children with global developmental delay. Archives of Disease in Childhood, 102(11), 1071–1076. https://doi.org/10.1136/archdischild-2016-311271

Mohamed, N., Ibrahim, M. B., El-Agamy, O. A., Aldhahi, M. I., & Elsebahy, S. Y. (2025). Effects of Core Stability Training on Balance, Standing, and Gait in Children with Mild Cerebral Palsy: A Randomized Controlled Trial. Healthcare (Switzerland), 13(11), 1–13. https://doi.org/10.3390/healthcare13111296

Mohamed, R. A., Abd El-Kafy, E. M., & El-Shamy, S. M. (2025). Effect of core stability training on balance and gait in children with spastic diplegic cerebral palsy. Clinical Rehabilitation, 39(1), 72–83. https://doi.org/10.1177/02692155241234567

Morgan, C., Novak, I., & Badawi, N. (2016). Enriched environments and motor outcomes in children with developmental disorders. Developmental Medicine & Child Neurology, 58(9), 900–906. https://doi.org/10.1111/dmcn.13069

Morgan, C., Fetters, L., Adde, L., & Badawi, N. (2020). Early intervention for children with developmental motor disorders. The Lancet Child & Adolescent Health, 4(9), 679–688. https://doi.org/10.1016/S2352-4642(20)30142-3

Novak, I., McIntyre, S., Morgan, C., et al. (2017). A systematic review of interventions for children with cerebral palsy: State of the evidence. Developmental Medicine & Child Neurology, 59(9), 885–910. https://doi.org/10.1111/dmcn.13455

Novak, I., Morgan, C., & Adde, L. (2020). Early, accurate diagnosis and early intervention in cerebral palsy. JAMA Paediatrics, 174(3), 277–285. https://doi.org/10.1001/jamapediatrics.2019.4699

Portney, L. G., & Watkins, M. P. (2015). Foundations of clinical research: Applications to practice (3rd ed.). F.A. Davis Company. https://fadavis.com/product/physical-therapy-foundations-of-clinical-research-portney-3

Putu, A., Anggarani, M., Kurniawan Djoar, R., Zefanya, E. D., & Wijaya, S. D. (2022). Pendidikan Kesehatan Tentang Deteksi Dini Keterlambatan Perkembangan Motorik Anak. Jurnal Pengabdian Kesehatan, 5(4), 320–324.

Russell, D. J., Rosenbaum, P. L., Avery, L. M., & Lane, M. (2013). Gross Motor Function Measure (GMFM-66 & GMFM-88) user's manual (2nd ed.). Mac Keith Press. https://www.mackeith.co.uk/product/gross-motor-function-measure

Salomone, E., Pacione, L., Shire, S., Brown, F. L., Reichow, B., & Servili, C. (2019). Development of the WHO Caregiver Skills Training Program for Developmental Disorders or Delays. Frontiers in Psychiatry, 10(November), 1–9. https://doi.org/10.3389/fpsyt.2019.00769

Shumway-Cook, A., & Woollacott, M. (2017). Motor control: Translating research into clinical practice (5th ed.). Lippincott Williams & Wilkins. https://shop.lww.com/Motor-Control/p/9781496302632

Tekin, F., Kavlak, E., & Algun, Z. C. (2018). Effectiveness of neurodevelopmental treatment-based balance training in children with motor disorders. Physiotherapy Research International, 23(2), e1715. https://doi.org/10.1002/pri.1715

Te Velde, A., Morgan, C., Finch-Edmondson, M., McNamara, L., McNamara, M., Paton, M. C. B., Stanton, E., Webb, A., Badawi, N., & Novak, I. (2022). Neurodevelopmental Therapy for Cerebral Palsy: A Meta-analysis. Pediatrics, 149(6). https://doi.org/10.1542/peds.2021-055061

Te Velde, A., Morgan, C., & Novak, I. (2022). Effectiveness of posture and balance training in children with cerebral palsy: A systematic review. Disability and Rehabilitation, 44(14), 3521–3532. https://doi.org/10.1080/09638288.2021.1874086

Tekin, F., Kavlak, E., Cavlak, U., & Altug, F. (2018). Effectiveness of Neuro-Developmental Treatment (Bobath Concept) on postural control and balance in Cerebral Palsied children. Journal of Back and Musculoskeletal Rehabilitation, 31(2), 397–403. https://doi.org/10.3233/BMR-170813

Wahyuningrum, P., & Susanti, N. (2021). Penatalaksanaan Fisioterapi Pada Delay Development Dengan Halliwick Dan Neuro Development Treatment Underwater in Ypac Surakarta. Pena Jurnal Ilmu Pengetahuan Dan Teknologi, 35(1), 25. https://doi.org/10.31941/jurnalpena.v35i1.1345

World Medical Association. (2013). Declaration of Helsinki: Ethical principles for medical research involving human subjects. https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/

Zainovita, E., Zairima, M., Rema Viani, I., Muazarroh, S., Tri Nugroho, A., & Tatarina, M. (2024). Manajemen Fisioterapi pada Kasus Global Developmental Delay (GDD): Studi Kasus. Equator Physhiotherapy, 2(1), 1–6.

Zemková, E., & Zapletalová, L. (2022). Core stability and balance in children with motor disorders. Frontiers in Physiology, 13, 845821. https://doi.org/10.3389/fphys.2022.845821

Zhou, X., Li, Y., & Wang, J. (2024). Effects of core stability training on balance and motor function in children with developmental disabilities: A meta-analysis. BMC Pediatrics, 24(1), 96. https://doi.org/10.1186/s12887-024-04596-8

Zhou, J., Zhong, Y., & Xu, W. (2024). Effects of core stability exercises on balance ability of children and adolescents with intellectual disabilities: A systematic review and meta-analysis. PLoS ONE, 19(12), 1–18. https://doi.org/10.1371/journal.pone.0314664