

Tele-rehabilitation Improves Gross Motor Development in Children with Developmental Delay: A Quasi-experimental Study

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Abstract

Background: Developmental delay is characterized by delayed achievement of developmental milestones, particularly gross motor skills, which may adversely affect children's functional independence and long-term development. Home Exercise Programs (HEPs) are widely used in pediatric physiotherapy; however, caregiver adherence remains challenging. Tele-rehabilitation may improve treatment continuity through remote supervision and ongoing therapist-caregiver communication.

Objective: To evaluate changes in gross motor development following a tele-rehabilitation-supported HEP among children aged 3 months to 2 years with developmental delay.

Methods: This quasi-experimental one-group pretest-posttest study included 30 children recruited using purposive sampling. Participants completed a four-week tele-rehabilitation-supported HEP three times weekly. Gross motor development was assessed using the Denver Developmental Screening Test (DDST), while the Maternal and Child Health Handbook (KIA) was used as a developmental screening instrument. Data were analyzed using the Shapiro-Wilk test and the Wilcoxon Signed Rank Test.

Results: Mean DDST scores increased from 9.43 ± 1.68 to 13.60 ± 2.62 , with a mean improvement of 4.17 points. KIA scores increased from 6.20 ± 1.46 to 10.63 ± 2.94 . Wilcoxon analysis demonstrated significant improvement following the intervention ($Z = -4.736$; $p < 0.001$). Effect size and confidence intervals could not be reported because the original dataset was unavailable.

Conclusion: A four-week tele-rehabilitation-supported HEP was associated with improved gross motor development in children with developmental delay. Controlled studies with comprehensive statistical reporting are recommended.

Keywords:

Developmental Delay; Exercise Therapy; Motor Skills; Physical Therapy Modalities; Telerehabilitation

Introduction

Developmental delay (DD) is a neurodevelopmental condition characterized by delayed attainment of age-appropriate developmental milestones in one or more developmental domains, including gross motor, fine motor, language, cognitive, and personal-social development. Among these domains, gross motor development plays a fundamental role because it provides the foundation for postural control, mobility, environmental exploration, and participation in daily activities. Delayed acquisition of gross motor milestones during infancy, including rolling, sitting, crawling, standing, and walking, may adversely affect subsequent cognitive development, learning ability, social participation, and overall functional independence if early intervention is not provided. Consequently, early identification followed by timely rehabilitation is essential to optimize developmental outcomes during the critical period of neuroplasticity.^{1,2}

Developmental delay remains an important public health concern worldwide. Previous epidemiological reports cited in the original study estimated the prevalence of developmental delay to range from approximately 12–16% in the United States, 24% in Thailand, 22% in Argentina, and 13–18% in Indonesia.^{1,3–5} Although these reports demonstrate that developmental delay continues to affect a substantial proportion of children, disparities in early detection and rehabilitation services remain particularly evident in low and middle income countries. In Indonesia, developmental surveillance has been integrated into primary child healthcare through the Maternal and Child Health Handbook (Buku Kesehatan Ibu dan Anak [KIA]); however, accessibility to pediatric rehabilitation services remains uneven across geographical regions, creating barriers to timely intervention and continuity of care.⁶

Children with gross motor developmental delay frequently demonstrate impaired postural control, reduced muscle strength, abnormal muscle tone, poor balance, and impaired motor coordination. These impairments may restrict age-appropriate functional activities, reduce opportunities for motor learning, and limit participation in daily life. Over time, persistent motor limitations may negatively influence educational readiness, psychosocial development, caregiver burden, and quality of life. Consequently, pediatric physiotherapy has an important role in facilitating motor development through individualized interventions that promote functional movement, active participation, and family involvement throughout the rehabilitation process.^{2,7}

Conventional pediatric physiotherapy primarily relies on repeated face-to-face sessions for assessment, exercise instruction, progress monitoring, and modification of therapeutic programs. Although this approach remains the standard model of care, regular attendance at rehabilitation facilities may be difficult for many families because of transportation costs, geographical distance, limited availability of pediatric rehabilitation services, work commitments, and scheduling constraints. These barriers may reduce treatment continuity, limit caregiver adherence to prescribed exercises, and ultimately compromise rehabilitation outcomes.⁸ Therefore, alternative service delivery strategies that extend professional support beyond clinical settings are increasingly required.

A Home Exercise Program (HEP) has become an integral component of family-centered pediatric rehabilitation because it enables therapeutic exercises prescribed by physiotherapists to be performed regularly within the child's natural environment. Successful implementation of an HEP depends not only on appropriate exercise prescription but also on caregiver understanding,

confidence, motivation, and long-term adherence. Nevertheless, maintaining exercise fidelity without continuous professional supervision remains challenging, and inconsistent implementation may reduce the effectiveness of rehabilitation.^{8,9}

Advances in digital health have facilitated the integration of tele-rehabilitation into pediatric physiotherapy. Tele-rehabilitation enables physiotherapists to provide remote consultation, exercise supervision, caregiver education, progress monitoring, and timely feedback using synchronous or asynchronous communication technologies. Rather than replacing conventional face-to-face services, tele-rehabilitation functions as a complementary strategy that supports treatment continuity, strengthens therapist-caregiver communication, and facilitates individualized modification of rehabilitation programs according to children's developmental progress. Previous studies have demonstrated that tele-rehabilitation is feasible, acceptable, and capable of improving access to rehabilitation services across various clinical settings.^{8,10,11}

Several recent studies have also reported positive outcomes following tele-rehabilitation-supported interventions in pediatric populations. Remote supervision combined with caregiver-mediated rehabilitation has been associated with improvements in motor performance, participation in daily activities, caregiver satisfaction, and adherence to prescribed exercise programs. Likewise, structured HEPs supported by regular professional monitoring have demonstrated favorable effects on motor development by increasing exercise intensity and reinforcing active caregiver participation. Collectively, these findings suggest that integrating tele-rehabilitation with home-based pediatric physiotherapy may strengthen family-centered rehabilitation and improve continuity of care.^{8,9,11,12}

Despite these encouraging findings, important knowledge gaps remain. Most previous studies have focused on children with cerebral palsy, developmental coordination disorder, or other specific neurological conditions, whereas evidence regarding tele-rehabilitation for children with developmental delay during the first two years of life remains limited. Furthermore, much of the available evidence originates from high income countries with healthcare systems, digital infrastructure, and rehabilitation resources that differ considerably from those in Indonesia. Consequently, the applicability of these findings to Indonesian community-based pediatric physiotherapy remains uncertain. Evidence evaluating tele-rehabilitation as a strategy to support caregiver implementation of HEPs within routine pediatric rehabilitation services in Indonesia is still limited, highlighting the need for context-specific investigations.¹³

Preliminary observations conducted at Rumah Edukasi, Sleman, Yogyakarta, identified 30 children aged between 3 months and 2 years with gross motor developmental delay who required ongoing physiotherapy intervention. Although caregivers had received HEP education, maintaining adherence and ensuring correct exercise performance remained challenging during home implementation. To address these issues, tele-rehabilitation was incorporated as a supportive strategy to facilitate continuous supervision, reinforce caregiver education, and maintain communication between physiotherapists and families throughout the rehabilitation process. These observations provided the practical rationale for evaluating this model of service delivery within a community-based rehabilitation setting.¹⁴

The novelty of the present study lies in evaluating the implementation of tele-rehabilitation as a supportive strategy for HEPs among Indonesian children aged 3 months to 2 years with developmental delay receiving community-based physiotherapy services. Unlike previous studies that primarily investigated tele-rehabilitation in other pediatric conditions or different healthcare environments, this study specifically examined its integration into routine clinical practice for children with developmental delay within the Indonesian context. The findings therefore contribute evidence regarding the feasibility of incorporating tele-rehabilitation into family-centered pediatric physiotherapy in resource-constrained community settings while identifying methodological issues that should be addressed in future investigations.¹⁵

Accordingly, this study aimed to evaluate changes in gross motor development following a four-week tele-rehabilitation-supported HEP among children aged 3 months to 2 years with developmental delay. It was hypothesized that participants would demonstrate higher gross motor development scores after completion of the intervention than at baseline. Considering the quasi-experimental one-group pretest-posttest design, the findings should be interpreted as evidence of improvement following the intervention rather than definitive evidence of a causal treatment effect.

Methods

This study employed a quantitative quasi-experimental design using a one-group pretest-posttest approach to evaluate changes in gross motor development following a tele-rehabilitation-supported Home Exercise Program (HEP) among children with developmental delay. Participants underwent baseline assessment before receiving the intervention and were reassessed immediately after completion of the intervention. Because no comparison group was included, the study was designed to evaluate changes over time within the same participants rather than establish a causal relationship between the intervention and the observed outcomes. The manuscript was prepared with reference to the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) Statement to improve reporting transparency and methodological completeness. However, several TREND reporting items could not be fully addressed because the corresponding information was unavailable in the original study documentation.¹⁵

The study was conducted at Rumah Edukasi, Sintokan, Wukirsari, Sleman, Yogyakarta, Indonesia. Data collection was undertaken from 14 April to 16 May 2026. This rehabilitation center routinely provides pediatric physiotherapy services for children with developmental delay, including caregiver education, home-based rehabilitation, and tele-rehabilitation support.

The target population comprised children with developmental delay receiving physiotherapy services at Rumah Edukasi during the study period. According to the original study records, 163 children were registered at the rehabilitation center. Participants were recruited using purposive sampling because only children meeting predefined clinical, technical, and logistical eligibility criteria were considered suitable for participation. This sampling strategy ensured that all participants could complete the intervention according to the study protocol while maintaining intervention feasibility within routine clinical practice. Although purposive sampling was considered appropriate for this implementation study, it may reduce external validity and should therefore be considered when interpreting the generalizability of the findings.

Children were eligible if they fulfilled all of the following criteria: (1) had received HEP education through tele-rehabilitation; (2) were aged between 3 months and 2 years and had gross motor developmental delay; (3) had parents or caregivers who were cooperative and able to understand physiotherapist instructions; (4) had access to a smartphone capable of supporting Google Meet consultations; (5) had written informed consent provided by a parent or legal guardian; and (6) were willing to participate in tele-rehabilitation sessions three times weekly for four consecutive weeks. Children were excluded if informed consent was not obtained, if they had cerebral palsy or Down syndrome, or if they discontinued participation before completion of the intervention. Thirty children fulfilled the eligibility criteria and completed the study.

The original study did not report an a priori sample size calculation or statistical power analysis. Consequently, these methodological components cannot be added retrospectively without introducing unsupported information. This limitation should be considered when interpreting the statistical precision and generalizability of the findings.

Baseline demographic characteristics, including age, sex, body weight, height, body mass index (BMI), and attendance during tele-rehabilitation, were recorded before commencement of the intervention. Gross motor development was evaluated before and after the intervention using the Denver Developmental Screening Test (DDST), which served as the primary outcome measure. Developmental status was additionally documented using the Indonesian Maternal and Child Health Handbook (Buku Kesehatan Ibu dan Anak [KIA]). Consistent with the original study protocol, the KIA Handbook functioned solely as a developmental screening instrument supporting clinical documentation rather than as the primary outcome measure. Therefore, inferential statistical analyses were performed only for DDST scores.

The DDST is a standardized developmental screening instrument designed to evaluate developmental performance across multiple domains. In the present study, only the gross motor domain was analyzed because it directly corresponded to the study objective. The KIA Handbook was used to support routine developmental monitoring according to the Indonesian child health surveillance program. The original study did not report evidence regarding instrument validity, reliability, examiner training, or inter-rater agreement. Accordingly, these methodological characteristics cannot be incorporated without introducing information beyond the original study documentation.¹⁶

Participants received a structured HEP supervised through synchronous tele-rehabilitation for four consecutive weeks. Tele-rehabilitation sessions were conducted three times each week using Google Meet, with each session lasting approximately 30 minutes. During every session, the physiotherapist demonstrated therapeutic exercises, observed caregiver performance, corrected inappropriate movement patterns when necessary, provided real-time verbal feedback, monitored the child's progress, and reinforced caregiver education to promote adherence throughout the intervention period.

The HEP consisted of therapeutic exercises individually prescribed according to each child's developmental status and gross motor abilities identified during the baseline assessment. Each prescribed activity was performed for ten repetitions during every supervised session. Exercise instructions were modified whenever necessary according to each participant's developmental progress and functional capacity. Consequently, the intervention followed an individualized rehabilitation approach rather than a standardized protocol for all participants. Nevertheless, the original study did not document the specific exercise content, progression criteria, exercise intensity, equipment used, or decision-making criteria for modifying the intervention. Therefore, complete replication of the intervention is not possible based solely on the available documentation, and several components recommended by the Template for Intervention Description and Replication (TIDieR) checklist remain unavailable.¹⁷

To improve intervention fidelity, physiotherapists maintained continuous communication with caregivers throughout the intervention by providing direct supervision during online consultations, correcting inappropriate exercise techniques, answering caregiver questions, reinforcing key educational messages, and encouraging implementation of the prescribed HEP between scheduled sessions. Attendance at every tele-rehabilitation session was recorded as an indicator of participant engagement; however, adherence to unsupervised home exercise performed outside scheduled online sessions was not objectively measured in the original study.

The participant selection process and study progression are summarized in Figure 1. The original study documented that 163 children were registered at the rehabilitation center, of whom 30 fulfilled the eligibility criteria and completed the intervention. No participant withdrew during the study period. However, the number of individuals excluded at each screening stage and the reasons for exclusion were not reported in the original dataset. Consequently, the participant flow cannot be fully reconstructed according to the TREND Statement without introducing unsupported assumptions. A TREND-style flow diagram may nevertheless be presented using only the verified information available in the original study records.¹⁵

Before inferential analysis, data distribution was assessed using the Shapiro-Wilk test. Continuous variables were summarized as means and standard deviations, whereas categorical variables were presented as frequencies and percentages. Because DDST scores were not normally distributed, pre-intervention and post-intervention differences were analyzed using the Wilcoxon Signed Rank Test with a significance level of 0.05. Statistical results were reported using Z statistics and p values. The original study did not report the statistical software used, effect size estimates, or confidence intervals. Since the original dataset was unavailable for reanalysis, these parameters cannot be added without compromising scientific integrity and are therefore acknowledged as reporting limitations.

Several potential sources of bias should be considered when interpreting the study findings. The one-group pretest-posttest design is susceptible to maturation effects, history effects, regression toward the mean, testing effects, and the absence of a concurrent comparison group. Although all participants underwent identical assessment procedures and completed the intervention within the same four-week period under standardized tele-rehabilitation supervision, these procedures reduce but do not eliminate the inherent risk of bias associated with non-randomized before-and-after studies. Furthermore, assessor blinding was not reported in the original study, introducing the possibility of measurement bias. Consequently, the findings should be interpreted as evidence of improvement observed after the intervention rather than definitive evidence of treatment effectiveness.

Ethical approval was obtained under approval number **116/S/IV/S1-FIS/2026**, and written informed consent was obtained from all parents or legal guardians before participant enrollment. The original study did not identify the name of the approving ethics committee. Therefore, only the documented approval number is reported to maintain consistency with the original research records.

Results

A total of 30 children with developmental delay completed the four-week tele-rehabilitation-supported Home Exercise Program (HEP), and all participants were included in the final analysis. No participants withdrew during the intervention period. The results are presented sequentially to describe participant characteristics, intervention adherence, descriptive changes in developmental outcomes, and inferential statistical findings evaluating changes in gross motor development.

Baseline demographic characteristics were analyzed to describe the study population and provide clinical context for interpretation of the intervention outcomes. The distribution of participant characteristics is presented in Table 1.

Table 1. Baseline Characteristics of Participants (n = 30)

Characteristic	n	%
Age		
9–12 months	8	26.7
13–18 months	13	43.3
19–24 months	9	30.0
Sex		
Male	14	46.7
Female	16	53.3
Body weight		
6–9 kg	24	80.0
10–12 kg	5	16.7
13–15 kg	1	3.3
Height		
60–70 cm	6	20.0
71–80 cm	15	50.0
81–90 cm	7	23.3
91–100 cm	2	6.7
Body mass index		
Underweight	6	20.0
Normal	23	76.7
Overweight	1	3.3

The study population was relatively homogeneous. Most participants were aged 13–18 months (43.3%), female (53.3%), weighed between 6 and 9 kg (80.0%), had a height of 71–80 cm (50.0%), and had a normal body mass index (76.7%). Overall, these findings indicate that the intervention was predominantly implemented among toddlers with nutritional status within the normal range. Participant attendance was evaluated to describe engagement with the tele-rehabilitation sessions throughout the intervention period. Attendance records are summarized in Table 2.

Table 2. Attendance During Tele-rehabilitation

Number of sessions	n	%
10	2	6.7
11	1	3.3
12	27	90.0

Attendance remained consistently high during the four-week intervention. Twenty-seven participants (90.0%) completed all scheduled sessions, whereas only three participants missed one or two sessions. These findings suggest good caregiver engagement with the tele-rehabilitation process. Nevertheless, attendance reflects participation in supervised online consultations only and should not be interpreted as a direct measure of adherence to home exercises performed outside scheduled sessions.

Developmental status was also documented using the Maternal and Child Health Handbook (KIA) to complement routine clinical assessment. As specified in the study protocol, KIA served as a developmental screening instrument rather than the primary outcome measure. Therefore, only descriptive findings are presented in Table 3.

Table 3. Gross Motor Development Based on KIA Assessment

Variable	Pre-intervention	Post-intervention	Mean difference
Mean	6.20	10.63	4.43
Standard deviation	1.46	2.94	1.48
Minimum	5	5	0
Maximum	11	16	5

The descriptive findings indicate higher KIA developmental screening scores following completion of the intervention. However, because the KIA Handbook functioned solely as a supporting developmental screening instrument, no inferential statistical analysis was performed. Consequently, these findings should be interpreted as descriptive clinical information rather than evidence supporting the primary study hypothesis. The primary outcome of this study was gross motor development assessed using the Denver Developmental Screening Test (DDST). Descriptive changes in DDST scores before and after the intervention are presented in Table 4.

Table 4. DDST Scores Before and After the Intervention

Variable	Pre-intervention	Post-intervention	Mean difference
Mean	9.43	13.60	4.17
Standard deviation	1.68	2.62	0.95
Minimum	8	8	0
Maximum	15	17	2

Participants demonstrated higher DDST scores following completion of the four-week intervention. Mean scores increased by 4.17 points, indicating improvement in gross motor developmental performance during the intervention period. Although descriptive findings demonstrated consistent improvement across the study population, statistical significance was evaluated through inferential analysis after assessment of data distribution. Before inferential statistical testing, data normality was evaluated to determine the appropriate analytical approach. The results of the Shapiro-Wilk normality test are presented in Table 5.

Table 5. Shapiro-Wilk Normality Test

Variable	Statistic	df	p value
DDST pre-intervention	0.790	30	<0.001
DDST post-intervention	0.871	30	0.002

Both pre-intervention and post-intervention DDST scores showed significant departures from normality ($p < 0.05$). Accordingly, a non-parametric statistical approach was considered appropriate, and differences between pre-intervention and post-intervention scores were subsequently analyzed using the Wilcoxon Signed Rank Test. The primary hypothesis was evaluated by comparing DDST scores before and after the intervention using the Wilcoxon Signed Rank Test. The results are presented in Table 6.

Table 6. Wilcoxon Signed Rank Test

Variable	Value
Positive ranks	29
Negative ranks	0
Ties	1
Z statistic	-4.736
p value	<0.001

The inferential analysis demonstrated that 29 participants achieved higher DDST scores after the intervention, one participant showed no change, and none demonstrated deterioration. The Wilcoxon Signed Rank Test identified a statistically significant difference between baseline and post-intervention assessments ($Z = -4.736$; $p < 0.001$), indicating that gross motor development improved during the intervention period.

The original study did not report effect size estimates or confidence intervals, and the original dataset was unavailable for reanalysis. Consequently, these statistical parameters cannot be presented without introducing unsupported analyses. Likewise, although KIA screening scores also increased descriptively after the intervention, inferential statistical analysis was intentionally restricted to DDST because DDST constituted the predefined primary outcome measure.¹⁹

Overall, the findings consistently demonstrated improvement in gross motor developmental performance following the four-week tele-rehabilitation-supported HEP. Nevertheless, because the study employed a one-group pretest-posttest design without a concurrent comparison group, these findings should be interpreted as evidence of improvement observed after the intervention rather than definitive evidence of a causal treatment effect.

Discussion

The present study demonstrated that children with developmental delay experienced improved gross motor development following participation in a four-week Home Exercise Program (HEP) supported by tele-rehabilitation. Gross motor performance, measured using the Denver Developmental Screening Test (DDST), increased from a mean score of 9.43 ± 1.68 at baseline to 13.60 ± 2.62 after the intervention, representing a mean improvement of 4.17 points. Inferential analysis using the Wilcoxon Signed Rank Test confirmed that this improvement was statistically significant ($Z = -4.736$; $p < 0.001$). These findings indicate that participants demonstrated better gross motor performance after completion of the intervention period. However, because this study employed a one-group pretest-posttest design without a comparison group, the observed improvement should be interpreted as evidence of change occurring after the intervention rather than definitive evidence that the intervention alone caused the observed outcomes.

One plausible explanation for the observed improvement is that tele-rehabilitation enhanced the implementation of the prescribed HEP by strengthening communication between physiotherapists and caregivers. Regular online supervision enabled physiotherapists to observe exercise performance, provide immediate corrective feedback, reinforce caregiver education, and address practical difficulties encountered during home exercise sessions. Such continuous interaction may have increased caregiver confidence, promoted more consistent implementation of therapeutic exercises, and reduced the likelihood of inappropriate exercise performance. The high attendance observed in the present study, with 90.0% of participants completing all scheduled tele-rehabilitation sessions, further supports the feasibility and acceptability of integrating remote supervision into routine pediatric physiotherapy services. Nevertheless, attendance should be interpreted as an indicator of participation in supervised sessions rather than a direct measure of adherence to exercises performed independently between consultations.

The present findings are consistent with previous investigations reporting favorable outcomes of tele-rehabilitation in pediatric rehabilitation. Studies included in the original literature review have shown that structured tele-rehabilitation can improve motor performance, facilitate participation in daily activities, and increase caregiver satisfaction by maintaining regular interaction between rehabilitation professionals and families. Likewise, professionally supervised HEPs have been associated with greater exercise adherence and more favorable developmental outcomes than unsupervised home-based interventions. Collectively, these findings support the concept that tele-rehabilitation may function as an effective adjunct to conventional pediatric physiotherapy by extending professional supervision beyond healthcare facilities and strengthening family participation in rehabilitation.^{8,9,12}

The improvement observed in this study may also be interpreted in light of contemporary motor learning and neuroplasticity theories.²⁰ During early childhood, repeated performance of developmentally appropriate motor activities provides opportunities for task-specific practice, sensory integration, postural adaptation, and neuromuscular coordination, all of which contribute to motor skill acquisition. Home-based therapeutic exercises performed consistently within the child's natural environment may increase the frequency of meaningful practice beyond that achievable through periodic outpatient visits alone. Tele-rehabilitation may further support this process by ensuring that caregivers perform therapeutic activities correctly and consistently under professional guidance. However, these mechanisms were not directly evaluated in the present study and therefore should be regarded as theoretical explanations supported by previous rehabilitation literature rather than experimentally confirmed findings.²¹

An additional strength of the intervention was its emphasis on family-centered rehabilitation. Rather than positioning caregivers as passive recipients of professional advice, the intervention actively involved them in planning and implementing daily therapeutic activities. Through regular tele-rehabilitation sessions, caregivers received individualized instruction, practical demonstrations, continuous feedback, and opportunities to discuss challenges encountered during home exercise implementation. Such collaborative interaction may enhance caregiver competence and confidence while encouraging sustained engagement throughout the rehabilitation process. Family-centered rehabilitation has increasingly been recognized as an essential principle in pediatric physiotherapy because caregivers provide the majority of developmental stimulation during children's everyday activities outside formal healthcare settings.^{8,9}

From a clinical perspective, the findings suggest that tele-rehabilitation may represent a practical strategy for maintaining continuity of pediatric physiotherapy, particularly for families experiencing geographical, financial, or logistical barriers to frequent face-to-face visits. By extending professional supervision into the home environment, tele-rehabilitation has the potential to reinforce caregiver adherence, facilitate early identification of implementation difficulties, and enable timely modification of therapeutic programs according to children's developmental progress. Accordingly, tele-rehabilitation should be viewed as a complementary component of family-centered physiotherapy rather than a replacement for direct clinical assessment and treatment. Integration of remote supervision with conventional rehabilitation may provide a more flexible model of care while preserving opportunities for individualized therapeutic decision-making.

Although statistically significant improvement was observed, the clinical magnitude of the intervention effect cannot be fully determined because the original study did not report effect size estimates, confidence intervals, or minimal clinically important differences. Consequently, the available findings demonstrate statistical improvement but do not permit quantitative evaluation of the practical importance of the observed changes. Future investigations should incorporate comprehensive statistical reporting, including effect size and confidence intervals, to facilitate interpretation of clinical relevance, comparison across studies, and evidence synthesis in systematic reviews and meta-analyses.²²

Several methodological limitations should be acknowledged. First, the one-group pretest-posttest design is susceptible to threats to internal validity, including maturation, history effects, regression toward the mean, and repeated testing effects. Because no concurrent comparison group was included, improvement observed during the intervention period cannot be attributed exclusively to tele-rehabilitation or the HEP. Second, purposive sampling from a single rehabilitation center together with the relatively small sample size may limit external validity and reduce the generalizability of the findings to broader pediatric populations. Third, the intervention period lasted only four weeks, precluding evaluation of long-term maintenance of developmental improvements. Fourth, the original study did not report assessor blinding, creating the possibility of measurement bias. Finally, several methodological reporting items recommended by contemporary reporting guidelines, including sample size calculation, statistical software, effect size, confidence intervals, comprehensive intervention description according to the Template for Intervention Description and Replication (TIDieR), and psychometric properties of the assessment instruments, were unavailable in the original study documentation. These limitations should be considered when interpreting the findings and when comparing the results with those of future studies.

Future research should employ randomized controlled trials or controlled quasi-experimental designs involving larger and more representative multicenter populations to strengthen causal inference regarding the effectiveness of tele-rehabilitation for children with developmental delay. Longer follow-up periods are required to determine whether improvements are sustained beyond the intervention period. Future studies should also report participant flow according to the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) Statement, describe interventions comprehensively in accordance with the TIDieR checklist, evaluate caregiver adherence using standardized measures, include effect size estimates and confidence intervals, and report psychometric characteristics of outcome instruments to improve methodological transparency and facilitate comparison across studies.²³

Conclusion

This study demonstrated that children with developmental delay exhibited improved gross motor development following participation in a four-week tele-rehabilitation-supported Home Exercise Program (HEP). Gross motor performance, assessed using the Denver Developmental Screening Test (DDST), increased significantly between the pre-intervention and post-intervention assessments, indicating measurable improvement during the intervention period.

Within the methodological limitations of a quasi-experimental one-group pretest-posttest design, these findings suggest that tele-rehabilitation may represent a feasible strategy for supporting caregiver implementation of home-based pediatric physiotherapy and maintaining continuity of rehabilitation services for children with developmental delay. However, because no comparison group was included, the observed improvements should not be interpreted as definitive evidence of a causal treatment effect.

Future studies should employ randomized controlled trials or controlled quasi-experimental designs involving larger and more representative multicenter populations, longer follow-up periods, comprehensive intervention reporting in accordance with the Template for Intervention Description and Replication (TIDieR) checklist, adherence to the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) Statement, and complete statistical reporting, including effect size and confidence intervals, to strengthen the evidence supporting tele-rehabilitation in pediatric physiotherapy.

Study Limitations

Several limitations should be considered when interpreting the findings of this study. First, the quasi-experimental one-group pretest-posttest design without a comparison group limits the ability to establish a causal relationship between the intervention and the observed improvement because maturation, history effects, regression toward the mean, and repeated testing effects cannot be completely excluded.

Second, participants were recruited using purposive sampling from a single rehabilitation center. Consequently, the findings may not be fully generalizable to children with developmental delay receiving rehabilitation in different healthcare settings or geographical regions.

Third, the intervention was conducted over only four weeks, preventing evaluation of the long-term sustainability of improvements in gross motor development after completion of the intervention.

Fourth, several methodological details were unavailable in the original study documentation, including sample size calculation, assessor blinding, statistical software, psychometric properties of the DDST and the Maternal and Child Health Handbook (Buku Kesehatan Ibu dan Anak [KIA]), effect size, confidence intervals, and complete intervention reporting according to the TIDieR checklist. To preserve scientific integrity, these items were not reconstructed or estimated retrospectively.

Finally, caregiver attendance during scheduled tele-rehabilitation sessions was documented; however, adherence to prescribed home exercises performed outside supervised consultations was not objectively measured. Therefore, the consistency of exercise implementation between scheduled sessions could not be evaluated.

Clinical Implications

Despite these limitations, the findings have important implications for pediatric physiotherapy practice. Tele-rehabilitation may serve as a practical adjunct to conventional face-to-face physiotherapy by facilitating continuous communication between

physiotherapists and caregivers, reinforcing implementation of prescribed Home Exercise Programs, and improving continuity of rehabilitation services. This approach may be particularly valuable for families facing geographical, transportation, financial, or scheduling barriers that limit access to frequent in-person rehabilitation.²⁴

The intervention also supports the principles of family-centered care by actively involving caregivers in the rehabilitation process through regular education, supervision, and feedback. Strengthening caregiver competence may contribute to more consistent delivery of therapeutic activities within the child's natural environment and improve opportunities for daily motor practice.²⁵

Although the present findings are encouraging, tele-rehabilitation should be considered a complementary strategy rather than a replacement for direct clinical assessment and face-to-face physiotherapy. Individual clinical evaluation remains essential for determining therapeutic goals, monitoring developmental progress, and modifying intervention programs according to each child's changing functional needs.

Author Contribution

Slamet Basuki: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, Writing Original Draft, Project Administration.

Mianti Nurrisy Sutejo: Conceptualization, Methodology, Supervision, Validation, Writing Review and Editing.

Deasy Virka Sari: Methodology, Validation, Supervision, Writing Review and Editing.

Laksmi Dewi Adzillina: Validation, Formal Analysis, Writing Review and Editing.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this article.

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Ethics Statement

This study was conducted in accordance with the ethical principles for research involving human participants. Ethical approval was obtained under approval number 116/S/IV/S1-FIS/2026. Written informed consent was obtained from the parents or legal guardians of all participating children before enrollment in the study.

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