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The Effect of a Short-Term Functional Training Program on Motor Skill Improvement in Children with Cerebral Palsy

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ABSTRACT

Objective: The aim of this study is to prove the effect of a short-term functional training program on motor skill improvement in children with Cerebral palsy.

Methods and Materials: The research method used was a true-experimental design with a pretest-posttest control group design. A total of 20 male children with spastic CP, aged 10-22 years, were recruited from Sekolah Luar Biasa Tunadaksa Ringan (SLB D) Surakarta were randomly selected to be divided into two groups: control group without intervention (CGWI, n=10) and functional training intervention group (FTIG, n=10). The functional training program was carried out for 6 weeks with a frequency of 3x/week. Data collection involved measuring motor skills, such as hand-eye coordination using a ball throw and catch test with a tennis ball for 60 seconds. Hand muscle strength was evaluated using a Hand Grip Dynamometer. Data analysis was conducted using paired sample t-tests with a significance level of 5%.

Findings: The results of the analysis showed a significant difference in muscle strength between the control group without intervention (CGWI) and the functional training intervention group (FTIG) (Cohen's d = 7.242, p=0.001). Meanwhile, coordination there was also a significant difference (Cohen's d = 10.531, p=0.001).

Conclusion: This program shows potential as a valuable therapeutic intervention to enhance daily functioning and independence in children with CP.

Keywords: Disability status, functional training, pediatric rehabilitation, spastic CP motor skills.

Introduction

Cerebral palsy (CP) is the most common motor disorder in childhood, significantly impairing motor control, coordination, and strength, which are essential for achieving developmental milestones such as sitting, crawling, or walking independently (Olusanya et al., 2022). These impairments can lead to delays in motor milestones, such as sitting unassisted or developing symmetrical hand preference before the age of one, further hindering the child's ability to engage in daily activities and social interactions (Hutton, 2006; Veldman et al., 2016; Wondmagegn et al., 2024; Zubler et al., 2022). Beyond motor difficulties, CP can also affect communication, sensory processing, and cognitive abilities, which are critical for early learning and social participation (Arjunan et al., 2014; Bodimeade et al., 2013; Cummins et al., 2021; Mineo, 2020).

Children struggling with head or hand control, for example, may face challenges in exploring their environment—an important aspect of cognitive and emotional development (Wada et al., 2023). Additionally, mobility limitations can restrict access to educational and social experiences that foster intellectual and emotional growth (Gupta, 2001; Chawla, 2001). Therefore, early interventions are critical to addressing these developmental delays. Physical, occupational, and speech therapies have shown promise in enhancing motor skills, adaptability, and social participation in children with CP (Beckers et al., 2017; Jefferies et al., 2022; Wang et al., 2019; Wyatt et al., 2011). With appropriate support, children with CP can make significant progress, expanding their ability to interact with the world around them and improving their overall quality of life (Liu, 2012; Ryan et al., 2020).

Globally, CP affects an estimated 1 to 4 per 1,000 live births, with approximately 764,000 individuals living with the condition in the United States alone, including 500,000 children and adolescents (CDC, 2020; Liu, 2012; McIntyre et al., 2022). These figures underscore the need for effective and evidence-based interventions tailored to the specific needs of children with CP, considering the type and severity of their condition, as well as individual and family contexts (Morgan et al., 2021). Recent studies emphasize that a comprehensive, multidisciplinary approach is essential for helping children with CP achieve their full potential and improve their overall quality of life (Hoei-Hansen et al., 2023; Morgan et al., 2021). This includes standardized developmental screenings during routine health visits to identify motor delays early and ensure timely intervention (Faccioli et al., 2023). Therefore, both education and healthcare must work together to address motor development delays and support the holistic development of children (Jiang et al., 2024).

Intervention programs such as physical education for preschool-aged children focus on promoting coordination, strength, and balance—foundational skills that support lifelong physical and social development (Anttila et al., 2008; Elshafey et al., 2022; Otube & Karia, 2023). Among these, functional training programs have emerged as a promising intervention for children with CP. Unlike traditional therapies, functional training incorporates task-specific and repetitive activities aimed at strengthening fine and gross motor skills (Huang & Wu, 2022; Merino-Andrés et al., 2022; Yahagi et al., 2024).

One intervention with the potential to improve motor skills in children with CP is the Functional Training Program (Januszyk et al., 2023). Functional training programs involve exercises specifically designed to improve strength, flexibility, and coordination. Examples include wrist strengthening exercises using 1–3 kg dumbbells, squeezing sponge tennis balls, boccia exercises, and hand grip exercises with a grip strengthener (Dantas et al., 2020; Haris et al., 2020; Shilesh et al., 2023; Suárez-Iglesias et al., 2020). These exercises, conducted over six weeks with sessions lasting 30–60 minutes three times per week, are structured to enhance motor control, improve stability, and increase flexibility. Each session consists of 4–6 sets of 12–15 repetitions, with passive rest periods of 30–60 seconds between sets (Haris et al., 2020; Suárez-Iglesias et al., 2020).

Through regular participation in functional training programs, children with CP can achieve measurable improvements in motor skills, such as enhanced grip strength and coordination, which contribute to greater independence and quality of life (Haris et al., 2020; Hirata et al., 2021; Hoei-Hansen et al., 2023; Mohd Nordin et al., 2021; Subara-Zukic et al., 2024). Despite the wide range of therapeutic interventions available, evidence for the effectiveness of short-term functional training programs in improving motor skills in children with CP remains limited. Addressing this gap, this study aims to evaluate the impact of a six-week functional training program on

specific motor skills, such as grip strength, coordination, and flexibility, in children with cerebral palsy.

Methods and Materials

Study Design and Participants

This study used a true-experimental method with a pretest-posttest control group design. A total of 20 male children with spastic cerebral palsy, aged 10-22 years, were recruited from Sekolah Luar Biasa Tunadaksa Ringan (SLB D) Surakarta and underwent a six-week functional training program. Before starting the study, all subjects were informed verbally and in writing, and consent to participate was obtained by having their parents or guardians sign an informed consent form.

Instruments

Motor skill measurements, such as hand-eye coordination, were assessed using a ball throw and catch test with a tennis ball, thrown against a wall from a distance of one meter, and performed for 60 seconds. The test involved bouncing the tennis ball against the wall (wall pass) with the right hand and catching it with the left hand. Hand muscle strength in children with spastic cerebral palsy was measured using a Hand Grip Dynamometer before and after the intervention, with three measurements taken, and the average value was recorded (Raharjo et al., 2023). Motor skill measurements were taken twice: before (week 0) and 24 hours after the intervention (week 6).

Intervention

The functional training program was implemented and supervised by physical education teachers from SLB D Surakarta. Subjects were randomly divided into two groups: a control group without intervention (CGWI; n = 10) and a functional training intervention group (FTIG; n = 10). The functional training program included wrist strengthening exercises with a 1-3 kg dumbbell, squeezing a sponge tennis ball, boccia exercises, and hand grip exercises with a grip strengthener. These exercises were conducted for 30-60 minutes per session, performed in 4-6 sets of 12-15 repetitions, with passive rest between sets for 30-60 seconds. The exercises were conducted 3 times per week for 6 weeks.

Data Analysis

Data analysis techniques included normality testing using the Shapiro-Wilk test to assess the data distribution. For normally distributed data, differences were tested using Paired Samples t-Test and Independent Samples t-Test with a significance level of $p \leq 0.05$. Additionally, Cohen's d was used to measure the effect size between the two groups. All statistical analyses were performed using SPSS version 23.

Findings and Results

The results of this study on the effects of a short-term functional training program on improving motor skills in children with cerebral palsy (CP) show that, overall, there were no significant differences in the general characteristics of participants between the control group without intervention (CGWI) and the functional training intervention group (FTIG). The details of the analysis results are presented in Table 1. Meanwhile, the results of the analysis of muscle strength and coordination between pre-and post in each group are presented in Figures 1-2, and the detailed comparison of muscle strength and coordination between CGWI and FTIG is shown in Table 2.

Table 1 outlines the descriptive statistics for the study variables. The computed skewness and kurtosis values are all below one, thereby confirming that the normality assumption required for causal modeling is satisfied.

Table 1

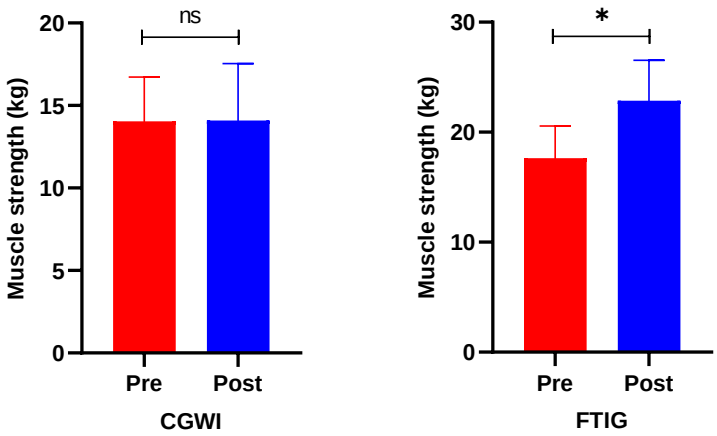
General characteristics of participants

Parameters	Unit	CGWI (n = 10)	FTIG (n = 10)	p-value
Age	yrs	17.00±2.79	17.40±2.72	0.749
Systolic blood pressure	mmHg	113.30±4.27	115.30±3.62	0.274
Diastolic blood pressure	mmHg	74.00±4.32	74.50±6.29	0.839
Heart rate rest	bpm	76.30±4.29	74.10±3.35	0.219
Oxygen saturation	%	98.50±0.71	98.30±0.48	0.471
Body temperature	°C	36.40±0.25	36.34±0.33	0.653

Description: *p*-value was evaluated with independent sample t-test. CGWI: control group without intervention; FTIG: functional training intervention group.

Figure 1

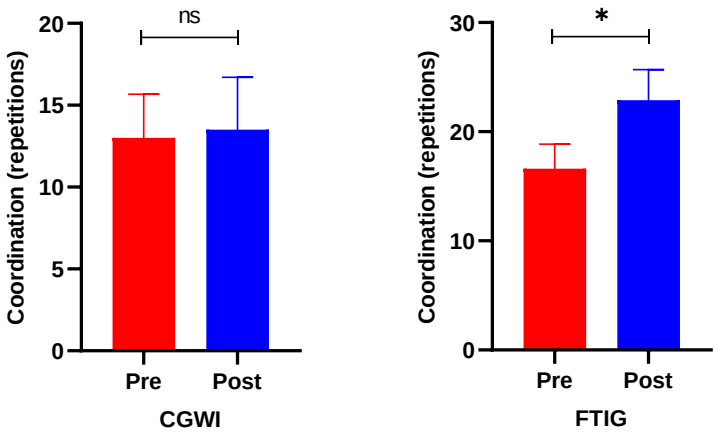
The results of muscle strength analysis between pre and post in each group



Description: (ns) not significant. (*) significant at pre ($p \leq 0.05$). *p*-value was evaluated with paired sample t-test.

Figure 2

The results of coordination analysis between pre and post in each group



Description: (ns) not significant. (*) significant at pre ($p \leq 0.05$). *p*-value was evaluated with paired sample t-test.

Table 2

Comparison of muscle strength and coordination between CGWI and FITG

Parameters	CGWI (*n* = 10)	FTIG (*n* = 10)	Effect Size	p-value
Pre-Muscle strength (kg)	14.04±2.69	17.63±2.94	-	0.267
Post-Muscle strength (kg)	14.09±3.45	22.87±3.68*	2.462	0.034
Δ-Muscle strength (kg)	0.05±0.49	5.24±0.89*	7.242	0.000
Pre-Coordination (repetitions)	13.00±2.67	16.60±2.25	-	0.161
Post-Coordination (repetitions)	13.50±3.21	22.90±2.79*	3.129	0.005
Δ-Coordination (repetitions)	0.50±1.27	6.30±2.11*	10.531	0.000

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Description: (*) significant at CGWI ($p \leq 0.05$). *p*-value was evaluated with independent sample t-test. Effect size evaluate using Cohen's d. (-) no effect size was observed.

Discussion and Conclusion

The findings of this study demonstrate that the Functional Training Program (FTP), which includes wrist strengthening exercises, squeezing a tennis ball, boccia exercises, and hand grip exercises, significantly improves motor skills in children with cerebral palsy (CP). Over the six-week program, notable improvements were observed in wrist stability, grip strength, hand-eye coordination, and muscle flexibility. These results affirm the efficacy of a structured and task-specific training approach in addressing motor deficits in children with CP, equipping them with essential skills to enhance independence and participation in daily activities. The observed outcomes align with the principles of neuroplasticity, which emphasize the brain's ability to reorganize and form new neural connections in response to targeted physical activities (Revelo Herrera & Leon-Rojas, 2024). Task-specific exercises, such as those in FTP, stimulate motor regions in the brain, including the motor cortex and basal ganglia, enhancing synaptic connectivity and improving motor control (Jamali et al., 2020; Roth & Ding, 2024). Additionally, the program's repetitive and intensive design may enhance the expression of neurotrophic factors, particularly brain-derived neurotrophic factor (BDNF) and insulin-like growth factor 1 (IGF-1), which are critical for neuronal growth, survival, and differentiation (Zou & Hao, 2024). These molecular changes contribute to improved coordination between the central nervous system and muscles, addressing disruptions in motor pathways commonly observed in children with CP.

Beyond neural adaptations, FTP may also benefit from its role in stimulating angiogenesis, which increases blood flow to the brain and muscles, thereby supporting energy metabolism and reducing muscle fatigue (Qi et al., 2022). This supports enhanced energy metabolism and muscle function, aiding better motor capabilities (Distefano & Goodpaster, 2018). Physical exercise has also been shown to regulate gene expression linked to anti-inflammatory processes, reducing the levels of pro-inflammatory cytokines such as TNF-α and increasing anti-inflammatory cytokines like IL-10 (Docherty et al., 2022; Scheffer & Latini, 2020). These anti-inflammatory effects are particularly beneficial for children with CP, as chronic inflammation can exacerbate motor dysfunction and impede neuronal repair (Qin et al., 2024). Collectively, these physiological and molecular changes provide a robust explanation for the significant improvements in grip strength and coordination observed in this study, which are critical functional outcomes for children with CP.

These findings are consistent with prior research on structured physical exercise programs for children with CP. For instance, studies by Januszyk et al. (2023), Merino-Andrés et al. (2022), Huang & Wu (2022), and Yahagi et al. (2024) have all demonstrated the benefits of repetitive and task-specific training in improving motor skills (Huang & Wu, 2022; Januszyk et al., 2023; Merino-Andrés et al., 2022; Yahagi et al., 2024). Bania et al. (2023) reported that resistance training alone enhances muscle strength and flexibility, but the addition of sensory-focused components, such as boccia, provides a synergistic effect by improving sensory integration and fine motor control (Bania et al., 2023). Boccia, in particular, not only serves as a physical exercise but also facilitates sensory-motor integration, as highlighted previously (Warutkar & Krishna Kovela, 2022). This integration supports the broader findings of this study, demonstrating that FTP's holistic approach addresses both the physical and sensory dimensions of motor development.

Compared to other rehabilitation methods, such as robot-assisted therapy or aquatic therapy, FTP offers several advantages in terms of accessibility and adaptability. While robot-assisted therapy has shown comparable improvements in motor coordination, with reported increases ranging from 12% to 18% (Merino-Andrés et al., 2022), FTP's reliance on minimal equipment makes it more practical for implementation in diverse settings, including schools and clinics. Moreover, its flexibility allows it to be tailored to the specific needs and abilities of individual children, enhancing its applicability across a broader spectrum of CP cases. Future research could explore hybrid approaches that integrate FTP with these other modalities to further maximize motor recovery and functional outcomes.

One of the key strengths of this study lies in the structured design of FTP, which addresses multiple aspects of motor development, including muscle

strength, sensory integration, and coordination, within a single program. The use of valid and reliable measurement tools ensures the robustness of the findings, and the multidisciplinary approach—incorporating input from physical therapists, neurologists, and educators—enhances the program's relevance and applicability. However, several limitations should be acknowledged. The relatively small sample size and focus on a specific age group and gender limit the generalizability of the results. Additionally, individual variability in CP severity and engagement in other physical activities, which were not controlled for, may have influenced the outcomes. The short duration of the intervention also restricts conclusions about the long-term sustainability of the observed benefits.

To build on these findings, future research should explore larger and more diverse samples, including children of different ages, genders, and CP subtypes. Investigating the optimal duration and intensity of FTP, such as extending the program to 8–12 weeks or varying the frequency of sessions, could provide further insights into maximizing its effectiveness. Additionally, studies examining the interaction between FTP and other complementary therapies, such as family-supported interventions or aquatic therapy, could help identify strategies for maximizing benefits. Mechanistic studies using neuroimaging or electrophysiological techniques could also shed light on the specific neural changes induced by FTP, such as the cortical reorganization or changes in motor-evoked potentials. Finally, practical implementation models, including cost-effectiveness analyses and training programs for therapists and educators, should be developed to facilitate the widespread adoption of FTP in school and clinical settings.

The findings of this study highlight the significant potential of FTP as an effective, accessible, and adaptable intervention for children with CP. By improving wrist stability, grip strength, and coordination, FTP empowers children to achieve greater independence and enhances their overall quality of life. As one of the few studies specifically focusing on short-term functional training, this research provides valuable evidence for integrating FTP into routine CP management protocols and paves the way for future advancements in therapy programs for children with CP.

The six-week Functional Training Program (FTP) demonstrated substantial efficacy in improving motor skills in children with cerebral palsy (CP). The analysis revealed significant improvements in both muscle strength and motor coordination. Specifically, the intervention group (FTIG) showed a large effect size compared to the control group without intervention (CGWI), with Cohen's d = 7.242 for muscle strength and Cohen's d = 10.531 for motor coordination ($p = 0.001$). These findings highlight the program's ability to address critical motor deficits effectively.

Beyond the physical benefits, FTP also provides an opportunity to support sensory integration, contributing to overall child development. The program's structured approach and task-specific design make it highly adaptable for both clinical and educational settings. For practical implementation, FTP can be integrated into school-based physical education curricula or incorporated into existing CP management protocols, with appropriate training provided for educators and therapists.

This study is among the few that specifically evaluate the impact of short-term functional training on motor skills in children with CP, filling an important gap in the literature. The results provide evidence-based insights into the potential of structured, targeted interventions, paving the way for future research to refine and expand the accessibility of FTP for diverse populations.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The entire intervention program applied in this study received approval from the Ethics Committee of Universitas Negeri Malang No:04.07.4/UN32.14.2.8/LT/2024. This study also adhered to the principles of the World Medical Association's Declaration of Helsinki regarding ethical conduct in research involving human subjects.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this study.

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