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Original Article

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Efficacy of low-level laser therapy combined with exercise on popliteal angle, gross motor function, and quality of life in children with spastic cerebral palsy: A double-blind, randomized-controlled study

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Abstract

Objectives: This study aims to evaluate the effects of low-level laser therapy (LLLT) combined with exercise on popliteal angle, gross motor function, and quality of life in children with spastic cerebral palsy (CP).

Patients and methods: This double-blind, randomized-controlled study included 21 children with spastic CP. Participants were randomly assigned to stretching plus LLLT (830 nm, 100 mW, 4 J/cm^2; n = 11) or stretching alone (n = 10) for eight weeks. Outcomes included popliteal angle, Gross Motor Function Measure-88 (GMFM-88), and Pediatric Quality of Life Inventory (PedsQL).

Results: Of the patients, 7 were male and 14 were female with a mean age of 9.62 ± 2.33 years (range, 5 to 14) years. Both groups showed significant within-group improvements in all parameters ($p < 0.05$). Compared to the control group, the LLLT group demonstrated significantly greater reductions in popliteal angles ($p < 0.05$). However, between-group differences for GMFM-88 and PedsQL scores were not statistically significant ($p = 0.072$, $p = 0.438$, and $p = 0.471$ for GMFM-88, PedQL General Fatigue and PedQL Sleep-related Fatigue respectively).

Conclusion: Combining LLLT with exercise demonstrates superior efficacy in reducing spasticity compared to exercise alone in children with CP. However, this combination cannot yield superior improvements in gross motor function or quality of life within the eight-week study period.

Keywords: Cerebral palsy, gross motor function, low-level laser therapy, muscle spasticity, quality of life.

Cerebral palsy (CP) is a non-progressive neurodevelopmental disorder characterized by abnormalities in movement, posture, and coordination resulting from early brain disturbances.[1] The global prevalence of CP is estimated to be between 1 to 5 cases per 1,000 live births.[1,2] As a leading contributor to childhood physical disability, it is frequently characterized by spasticity, muscle weakness, restricted joint movement, and balance deficits, which lead to substantial functional limitations and reduced quality of life.[3] Spasticity arising from disrupted

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corticospinal inhibitory pathways and increased spinal reflex activity comprises 70 to 80% of all cases.[3,4] In the lower limbs, spasticity frequently involves the hamstrings and gastrocnemius-soleus complex, increasing energy demands during movement and leading to rapid fatigue.[4]

In recent years, low-level laser therapy (LLLT) has emerged as a potential intervention for neuromuscular performance. Through photobiomodulation, LLLT enhances cellular metabolism, adenosine triphosphate (ATP) synthesis, and microcirculation while modulating collagen production and myogenesis.[5-7] In sports medicine, LLLT has been utilized to improve muscle metabolism and recovery.[6,8] Applying these mechanisms to pediatric rehabilitation, preliminary research suggests that LLLT may influence neuromuscular excitability, potentially reducing spasticity and improving muscle endurance in children with CP.[9]

The popliteal angle is the standard clinical measure for assessing hamstring tightness in CP.[10] While improvements in muscle properties through LLLT have the potential to facilitate enhanced movement patterns, evidence directly linking these physiological changes to gross motor function outcomes and health-related quality of life remains limited. Although preliminary data regarding spasticity are promising, the efficacy of LLLT in improving functional outcomes beyond conventional exercise therapy has not been definitively established.

In the present study, we aimed to evaluate the combined effects of LLLT and stretching exercises on the popliteal angle, gross motor function, and health-related quality of life in children with spastic CP compared to exercise therapy alone.

PATIENTS AND METHODS

This double-blind, randomized-controlled study was conducted at Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Diponegoro University between May 2023 and June 2023 in a community setting. Children with spastic CP recruited from local rehabilitation centers and non-profit community-based therapy programs in Semarang, Indonesia were included. Inclusion criteria were as follows: confirmed diagnosis of spastic quadriplegia due to CP, age ranging from five to 14 years, classification as level IV and V on the Gross Motor Function Classification System (GMFCS), presence of spasticity in the gastrocnemius-soleus and hamstring muscles, ability to cooperate with therapeutic programs, and caregivers capable of assisting with home exercise programs. Exclusion criteria were as follows: joint contractures in the lower extremities; previous lower extremity surgeries, seizure disorder; Face, Legs, Activity, Cry, and Consolability (FLACC) pain score > 3, acute inflammation or infection; receipt of botulinum toxin injections within six months prior to study; ongoing anti-spasticity therapy or interventions affecting muscle tone; or exposure to other therapeutic modalities within 72 h before the baseline assessment. Of the 52 children screened, 24 met the inclusion criteria and were assigned in a 1:1 ratio to either the LLLT or control group through a computer-randomized sequence. Allocation was concealed using sequentially numbered opaque sealed envelopes. Participants and outcome assessors were blinded to group assignment. During the intervention, two participants in the control group withdrew due to non-attendance at final data collection, and one participant in the intervention group withdrew after missing two consecutive LLLT sessions. The final analysis included 11 participants in the intervention group and 10 participants in the control group. The study flowchart in accordance with the CONSORT guidelines is depicted in Figure 1. A written informed consent was obtained from the parents and/or legal guardians of the patients. The study protocol was approved by the Ethics Committee for Medical Research, Faculty of Medicine, Diponegoro University/Dr. Kariadi General Hospital, Semarang (Date: April 18, 2024, No: 194/EC/KEPK/FK-UNDIP/V/2023). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Procedure

A BTL-5110 low-level laser (BTL Industries Ltd., Stevenage, Hertfordshire, UK) was used to deliver LLLT. Children in the experimental group received LLLT delivered at 830 nm using continuous wave emission, with a power output of 100 mW and energy dosage of 4 J/cm² per

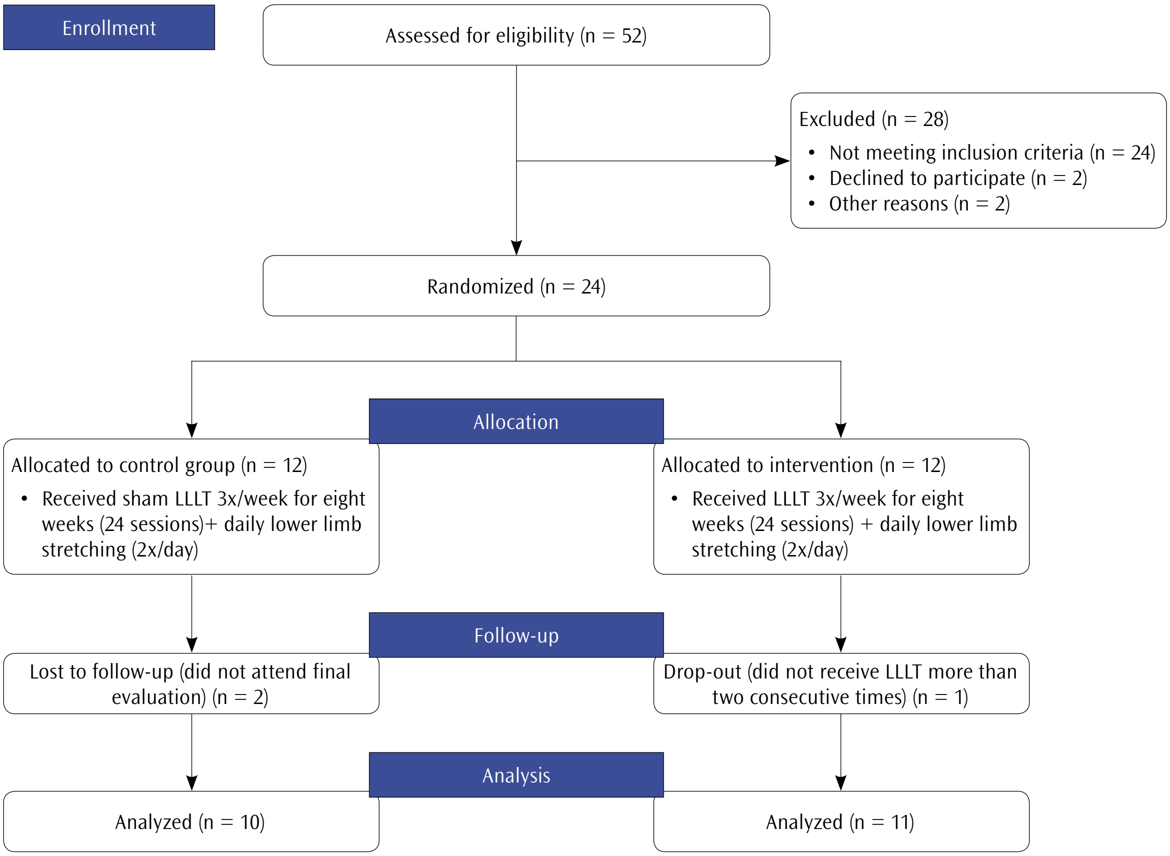

Figure 1. CONSORT flow diagram.

LLLT, low-level laser therapy.

spot. The spot area was approximately 0.5 cm^2. Each spot was irradiated for 30 sec. Twelve spots on the hamstring muscle and eight spots on the gastrocnemius muscle were treated during each session, as illustrated in Figure 2. These application sites were specifically selected to target the bulk of the muscle bellies of the hamstrings and gastrocnemius, where muscle spindle density and contractile tissue volume are highest, maximizing energy absorption to reduce spastic tone. The LLLT probe was positioned perpendicular to the skin surface during application. The control group was blinded to treatment allocation through the application of the laser device that was positioned and operated identically (including display illumination), but without active laser emission. (sham LLLT).

Participants in both the intervention and control groups performed the same standardized stretching protocol for eight weeks, five times per week, for 1 h per session. Three sessions were conducted at the treatment facility under the supervision of a physiotherapist, while two sessions were performed at home. During home sessions, passive stretching exercises were

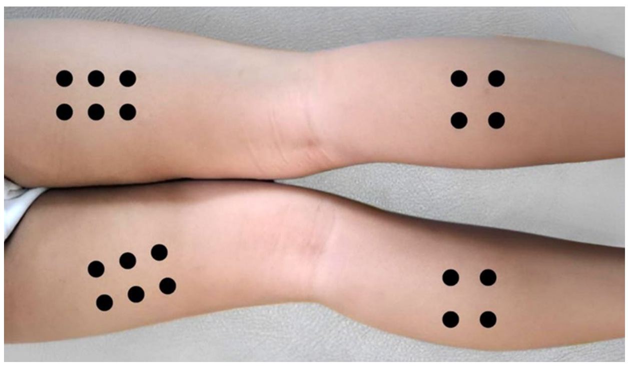

Figure 2. Twelve spots on the hamstring muscle and eight spots on the gastrocnemius muscle were treated during each session.

administered by the caregivers. The standardized stretching protocol specifically targeted the hamstring muscle complex (semitendinous, semimembranous, and biceps femoris) and the gastrocnemius muscle. Each static passive stretch was held at the point of mild tissue resistance for 30 sec, repeated five times per muscle group with a 15-sec rest interval between repetitions, and progress by gradually increasing the range of stretch as tolerance improved. Compliance was monitored through video recordings. Conventional exercise protocols were standardized across both groups to ensure comparability.

Outcome measurements

All assessments were conducted by an independent assessor blinded to group assignment. Evaluations were performed at baseline and immediately after the eight-week intervention period. Hamstring flexibility was evaluated by measuring the popliteal angle with a goniometer. The test is performed with the patient lying supine. The examiner flexes the hip to 90° for ensuring the opposite hip is neutral and, then, slowly extends the knee until firm resistance is met. The popliteal angle is the resulting acute angle between the long axis of the femur and the tibia.

To assess gross motor function, this study utilized the Gross Motor Function Measure-88 (GMFM-88) instrument. This measurement tool has been validated and demonstrates excellent inter-rater reliability (intraclass correlation coefficient [ICC] = 0.952-1.000) and test-retest reliability (ICC = 0.96-0.99), which is highly sensitive to changes in motor function and widely used to monitor gross motor development in children with CP. All five GMFM-88 dimensions were assessed: (A) lying and rolling, (B) sitting, (C) crawling and kneeling, (D) standing, and (E) walking, running, and jumping. Each item was rated on a four-point scale, and total scores were calculated as a percentage of the maximum possible score across all dimensions.

The Pediatric Quality of Life Inventory (PedsQL) was utilized to evaluate health-related quality of life. Data were obtained through structured interviews with parents or caregivers. Scores were converted to a 0-100 scale, where higher values reflecting better quality of life.

Statistical analysis

Sample size estimation was performed using G*Power version 3.1.9.7 software (Heinrich Heine University Düsseldorf, Düsseldorf, Germany), assuming an alpha error probability of 0.05 and a power of 80%. The minimum required sample size was determined to be 10 participants per group based on all relevant variables. To account for a potential 20% dropout rate, 12 participants were recruited for each group.

Statistical analysis was performed using the Stata® version 13.1 software (StataCorp, TX, USA). The Shapiro-Wilk test was applied to assess whether continuous data conformed to a normal distribution. Continuous data were presented in mean ± standard deviation (SD) or median (min-max), while categorical data were presented in number and frequency. Variables exhibiting normal distribution were compared between groups using the independent t-test. Nominal or categorical variables were compared using the chi-square test. A per-protocol analysis was conducted, including only participants who completed the full eight-week intervention. Within-group (pre- and post-intervention) comparisons were analyzed using either paired t-tests or Wilcoxon signed-rank tests, based on the distribution of the data. Between-group differences (intervention *vs.* control) were assessed using analysis of covariance (ANCOVA) or Quade's ANCOVA, as appropriate to the data's normality. Changes in continuous outcome measures, such as popliteal angle, were compared between groups using the ANCOVA or non-parametric alternatives based on data distribution. A p value of < 0.05 was considered statistically significant with 95% confidence interval (CI).

RESULTS

The final analysis included 11 participants in the intervention group and 10 participants in the control group. Of the patients, 7 were male and 14 were female with a mean age of 9.62 ± 2.33 years (range, 5 to 14) years. The body mass index (BMI) fell within the healthy weight range (5^{th}-85^{th} percentile) according to Centers for Disease Control and Prevention (CDC) criteria.

Table 1. Baseline characteristics of study participants

	Intervention group (n = 11)			Control group (n = 10)			
Parameters	n	%	Mean ± SD	n	%	Mean ± SD	*p*
Age (year)			9.73 ± 2.0			9.5 ± 2.76	0.830
Sex							0.537
Male	3	27.3		4	40		
Female	8	72.7		6	60		
Height (m)			1.20 ± 0.17			1.16 ± 0.19	0.624
Weight (kg)			22.7 ± 5.86			22.8 ± 10.07	0.986
Body mass index (kg/m^2)			16.1 ± 4.0			16.5 ± 3.9	0.786
GMFCS							1.000
IV	4	36.4		4	40		
V	7	64.6		6	60		

SD, standard deviation; GMFCS, gross motor function classification system.

Most patients performed daily stretching exercises prior to enrollment. There were no statistically significant differences between the groups regarding age, sex, height, weight, BMI, GMFCS level, or stretching frequency ($p > 0.05$). Baseline characteristics are summarized in Table 1.

As shown in Table 2, both groups exhibited significant within-group improvements in popliteal angles ($p < 0.05$ for both legs). In the intervention group, significant improvements were observed for both the right and left legs ($p < 0.05$). In the control group, significant changes were noted in the right leg ($p = 0.000$) and the left leg ($p = 0.012$). Between-group comparisons revealed that the reduction in popliteal angle was significantly greater in the intervention group compared to the control group ($p = 0.036$ for the right leg; $p = 0.003$ for the left leg).

Improvements were observed across all dimensions (A to E) of the GMFM-88 in both groups. Significant within-group improvements were detected from baseline to post-intervention ($p < 0.05$ for most dimensions). However, between-group comparisons of the change scores revealed no statistically significant differences across any dimension ($p > 0.05$, Table 2). These results indicate that while both groups benefited from the exercise program, the addition of LLLT did not significantly enhance gross motor function compared to exercise alone.

Both groups demonstrated significant within-group improvements in general fatigue and sleep-related fatigue domains ($p = 0.000$). However, no significant between-group differences were observed in the changes for general fatigue ($p = 0.438$) or sleep-related fatigue scores ($p = 0.471$, Table 2). No adverse events or complaints associated with the intervention were reported during the study period.

DISCUSSION

In the present study, we evaluated the combined effects of LLLT and stretching exercises on the popliteal angle, gross motor function, and health-related quality of life in children with spastic CP compared to exercise therapy alone. Our findings demonstrated that combining LLLT with stretching significantly reduced spasticity in children with spastic CP, as evidenced by superior improvements in the popliteal angle ($p < 0.05$), compared to exercise alone. These results align with Ragab et al.,[8] who reported the efficacy of LLLT in modulating muscle tone and elasticity.

The physiological basis for this reduction likely stems from photo biomodulation. In general, LLLT is believed to stimulate tissue repair, reduce inflammation, and enhance ATP synthesis.[11,12] By modulating prostaglandin synthesis and microcirculation, LLLT may reduce the extracellular matrix viscosity and hyaluronic acid deposition that contribute to muscle stiffness in spasticity.[13-15] While stretching addresses non-contractile tissue adaptations by improving extensibility,[16,17] the addition of LLLT appears to provide a synergistic effect by influencing

Table 2. Within- and between-group differences in popliteal angle, gross motor function measure-88, and pediatric quality of life inventory

	LLLT group (n = 11)				Control group (n = 10)				LLLT *vs.* Control	
	Baseline	After			Baseline	After			Adjusted between-group difference*	Effect size
Parameters	Mean ± SD	Mean ± SD	Mean difference	*p*	Mean ± SD	Mean ± SD	Mean difference	*p*	*p*	Cohen's d
Popliteal angle										
Left	53.64 ± 19.63	34.09 ± 22.67	19.55	0.000	64 ± 19.26	55.5 ± 14.6	8.50	0.012	0.003§	1.32
Right	49.09 ± 22.67	30.00 ± 22.13	20.91	0.000	64.50 ± 19.92	51.00 ± 22.33	13.50	0.000	0.036§	0.98
GMFM-88	31.23 ± 19.21	35.21 ± 18.21	3.99 ± 2.57	0.001¶	24.54 ± 20.51	26.86 ± 20.98	2.31 ± 1.42	0.001¶	0.072§	0.81
PedsQL										
General fatigue	43.19 ± 14.60	64 ± 19.40	20.81 ± 11.65	0.000¶*	51.67 ± 11.49	69.16 ± 13.37	17.49 ± 8.31	0.000¶*	0.438§	0.32
Sleep-related fatigue	53.01 ± 16.97	66.27 ± 21.53	13.26 ± 9.09	0.000¶*	55.01 ± 16.42	64.57 ± 16.34	9.56 ± 4.43	0.000¶*	0.471‡	0.52

LLLT, low-level laser therapy; SD, standard deviation; GMFM-88, Gross Motor Function Measure-88; PedsQL, Pediatric Quality of Life Inventory; § ANCOVA; ‡ Quade's ANCOVA; ¶ Paired t-test; $p < 0.05$ considered statistically significant.
* Between-group comparison represents baseline-adjusted post intervention differences evaluated using Analysis of Covariance (ANCOVA) or Quade's non parametric rank-based ANCOVA.

neuromuscular excitability and cellular metabolism.

Regarding functional outcomes, while both groups showed significant within-group improvements in GMFM-88 and PedsQL scores, the between-group differences were not statistically significant. This suggests that while LLLT reduces the "impairment" (spasticity), this does not immediately translate into "activity" or "participation" gains within an eight-week window. This is consistent with the International Classification of Functioning, Disability and Health (ICF) framework, where changes in body structure often require more time and intensive task-specific training to manifest as functional improvements.[18] Furthermore, the substantial gains from the standardized exercise program in the control group may have created a "ceiling effect," making it difficult to detect the incremental benefits of LLLT with our current sample size.[19-21]

To evaluate the clinical relevance of our outcomes beyond statistical significance, post-intervention changes were contextualized against distribution-based clinical thresholds (0.5 × baseline SD), a validated surrogate for Minimal Clinically Important Differences (MCIDs) when population-specific anchor studies in non-ambulatory cohorts are lacking. For popliteal angle, the 0.5 × SD threshold were 9.73° (left) and 10.65° (right). The LLLT group achieved mean reduction in popliteal angle (19.55° left, 20.91° right) that comfortably exceeded these clinical thresholds, demonstrating robust gain in muscle length. In comparison, the control group met the threshold on the right side (13.50°) but not on the left (8.50°), underscoring the superior and bilateral consistency of LLLT. For GMFM-88, neither group met the conservative 0.5 × SD threshold (9.93%) within the eight-week period, though the LLLT group demonstrated greater progress (3.99% *vs.* 2.31%). Finally, for PedQL general fatigue and sleep-related fatigue, both groups exceeded their respective distribution-based threshold (6.53 points for general fatigue, 8.35 points for sleep-related fatigue), indicating that the core exercise program provided clinically tangible fatigue relief for both groups, with LLLT offering incremental but statistically non-significant improvement.

Quality of life as assessed by PedsQL is influenced by factors beyond motor function, including cognitive, emotional, and environmental variables.[18,22,23] The lack of significant between-group differences here suggests that reducing lower-limb spasticity alone may not be sufficient to shift a parent's perception of overall quality of life in a short period.

Nonetheless, this study acknowledges several limitations that should be considered when interpreting the findings. First, the limited sample size may restrict the relevance of the findings to the wider population of children with spastic CP. Second, the duration of the intervention (eight weeks) may not have been sufficient to capture the potential long-term benefits of LLLT in rehabilitation; future studies should incorporate extended follow-up periods to enable a more thorough assessment of long-term treatment efficacy. Third, the nature of the intervention made it impractical to blind the physiotherapists administering LLLT, potentially introducing performance bias. Finally, the assessment of health-related quality of life was based on subjective reports from caregivers, which may have introduced reporting bias and impacted the accuracy of the perceived quality of life measurements.

In conclusion, our study results suggest that the combination of LLLT and stretching exercises exhibits superior efficacy in reducing spasticity in children with CP compared to exercise alone, as evidenced by significantly greater improvements in the popliteal angle. While LLLT has promising effects on muscle extensibility, it cannot lead to superior gains in gross motor function or quality of life within the eight-week study period. These findings suggest that LLLT serves as a valuable clinical adjunct specifically for the management of spasticity. Further research with larger cohorts and longer follow-up durations is warranted to determine if the reduction in spasticity can eventually translate into long-term functional and psychosocial benefits in pediatric rehabilitation.

Declaration of Conflicting Interests

The authors declare that there are no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Author Contributions

N.M., S.W.: Designed of study/supervision; E.S., A.P.: Coordinated the data collection and managed the clinical interventions; A.A., H.S.: Performed the statistical analysis and data interpretation; R.R., H.S.: Drafted the manuscript. All authors provided critical revisions for intellectual content and approved the final version for submission.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

AI Disclosure

The authors declare that artificial intelligence (AI) tools were not used, or were used solely for language editing, and had no role in data analysis, interpretation, or the formulation of conclusions. All scientific content, data interpretation, and conclusions are the sole responsibility of the authors. The authors further confirm that AI tools were not used to generate, fabricate, or 'hallucinate' references, and that all references have been carefully verified for accuracy.

REFERENCES

1. McIntyre S, Goldsmith S, Webb A, Ehlinger V, Hollung SJ, McConnell K, et al. Global prevalence of cerebral palsy: A systematic analysis. Dev Med Child Neurol 2022;64:1494-506. doi: 10.1111/dmcn.15346.
2. Oskoui M, Coutinho F, Dykeman J, Jetté N, Pringsheim T. An update on the prevalence of cerebral palsy: A systematic review and meta-analysis. Dev Med Child Neurol 2013;55:509-19. doi: 10.1111/dmcn.12080.
3. Alexander MA, Matthews DJ, Murphy KP, editors. Pediatric rehabilitation: principles and practice. 5th ed. New York: Demos Medical; 2015.
4. Berker N, Yalcin S. The HELP Guide to cerebral palsy. 2nd ed. Global Help; 2010.
5. Putri DE, Srilestari A, Abdurrohim K, Mangunatmadja I, Wahyuni LK. the effect of laser acupuncture on spasticity in children with spastic cerebral palsy. J Acupunct Meridian Stud 2020;13:152-6. doi: 10.1016/j.jams.2020.09.001.
6. das Neves MF, Dos Reis MC, de Andrade EA, Lima FP, Nicolau RA, Arisawa EÂ, et al. Effects of Low-Level Laser Therapy (LLLT 808 nm) on lower limb spastic muscle activity in chronic stroke patients. Lasers Med Sci 2016;31:1293-300. doi: 10.1007/s10103-016-1968-x.
7. Dabbous OA, Mostafa YM, El Noamany HA, El Shennawy SA, El Bagoury MA. Laser acupuncture as an adjunctive therapy for spastic cerebral palsy in children. Lasers Med Sci 2016;31:1061-7. doi: 10.1007/s10103-016-1951-6.
8. Ragab B, Balah OFA Osama A Mohamed MA. Effect of low level laser therapy on hamstring muscle tightness and calf muscle spasticity in children with cerebral pals. Turk J Physiother Rehabil 2021;32:27264-71.

9. Dos Reis FA, da Silva BA, Laraia EM, de Melo RM, Silva PH, Leal-Junior EC, et al. Effects of pre- or post-exercise low-level laser therapy (830 nm) on skeletal muscle fatigue and biochemical markers of recovery in humans: Double-blind placebo-controlled trial. Photomed Laser Surg 2014;32:106-12. doi: 10.1089/pho.2013.3617.
10. Hajibozorgi M, Hijmans JM, Greve C. The functional popliteal angle test can detect features of hamstring spasticity. Clin Biomech (Bristol) 2025;125:106523. doi: 10.1016/j.clinbiomech.2025.106523.
11. Hashmi JT, Huang YY, Osmani BZ, Sharma SK, Naeser MA, Hamblin MR. Role of low-level laser therapy in neurorehabilitation. PM R 2010;2:S292-305. doi: 10.1016/j.pmrj.2010.10.013.
12. Lee YU, Lee SK, Youn JI. Optical spectroscopic analysis of muscle spasticity for low-level laser therapy (LLLT). J Opt Soc Korea 2011;15:373-9. doi: 10.3807/JOSK.2011.15.4.373.
13. Kalkman BM, Bar-On L, O'Brien TD, Maganaris CN. Stretching interventions in children with cerebral palsy: Why are they ineffective in ımproving muscle function and how can we better their outcome? Front Physiol 2020;11:131. doi: 10.3389/fphys.2020.00131.
14. Howard JJ, Herzog W. Skeletal muscle in cerebral palsy: From belly to myofibril. Front Neurol 2021;12:620852. doi: 10.3389/fneur.2021.620852.
15. Mathewson MA, Lieber RL. Pathophysiology of muscle contractures in cerebral palsy. Phys Med Rehabil Clin N Am 2015;26:57-67. doi: 10.1016/j.pmr.2014.09.005.
16. Theis N, Korff T, Mohagheghi AA. Does long-term passive stretching alter muscle-tendon unit mechanics in children with spastic cerebral palsy? Clin Biomech (Bristol) 2015;30:1071-6. doi: 10.1016/j.clinbiomech.2015.09.004.
17. Kalkman BM, Holmes G, Bar-On L, Maganaris CN, Barton GJ, Bass A, et al. Resistance training combined with stretching increases tendon stiffness and is more effective than stretching alone in children with cerebral palsy: A randomized controlled trial. Front Pediatr 2019;7:333. doi: 10.3389/fped.2019.00333.
18. Abdelhalim SM, Shoukry KE, Alsharnoubi J. Effect of low-level laser therapy on quadriceps and foot muscle fatigue in children with spastic diplegia: A randomized controlled study. Lasers Med Sci 2023;38:182. doi: 10.1007/s10103-023-03841-y.
19. Liang X, Tan Z, Yun G, Cao J, Wang J, Liu Q, et al. Effectiveness of exercise interventions for children with cerebral palsy: A systematic review and meta-analysis of randomized controlled trials. J Rehabil Med 2021;53:jrm00176. doi: 10.2340/16501977-2772.
20. Pacheco-da-Costa S, Rodríguez-Costa I, Abuín-Porras V, Asúnsolo-Del-Barco Á, Calvo-Fuente V, Soto-Vidal C. Effectiveness of physiotherapy for improving participation, gross motor function, gait and balance in children and adolescents with cerebral palsy: Study protocol for a randomized controlled trial. J Clin Med 2025;14:2214. doi: 10.3390/jcm14072214.
21. Hsu CW, Kang YN, Tseng SH. Effects of therapeutic exercise intensity on cerebral palsy outcomes: A systematic review with meta-regression of randomized clinical trials. Front Neurol 2019;10:657. doi: 10.3389/fneur.2019.00657.
22. Schenker R, Coster WJ, Parush S. Neuroimpairments, activity performance, and participation in children with cerebral palsy mainstreamed in elementary schools. Dev Med Child Neurol 2005;47:808-14. doi: 10.1017/S0012162205001714.
23. Lestari AF, Sitaresmi MN, Sutomo R, Ridhayani F. Factors affecting the health-related quality of life of children with cerebral palsy in Indonesia: A cross-sectional study. Child Health Nurs Res 2024;30:7-16. doi: 10.4094/chnr.2023.027.