How to Cite:
Gunawan, P. I., Lusiana, L., Noviandi, R., & Samosir, S. M. (2022). Combination of standard physical therapy with partial body weight supported treadmill training in children with spastic diplegic cerebral palsy. *International Journal of Health Sciences*, *6*(S9), 1866–1877.
https://doi.org/10.53730/ijhs.v6nS9.12852

Combination of standard physical therapy with partial body weight supported treadmill training in children with spastic diplegic cerebral palsy

Prastiya Indra Gunawan
Neurology Division, Department of Child Health Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia
Correspondence author email: prastiya-i-g@fk.unair.ac.id

Lusiana
Neurology Division, Department of Child Health Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

Riza Noviandi
Neurology Division, Department of Child Health Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

Sunny Mariana Samosir
Neurology Division, Department of Child Health Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

***Abstract*---**Standard physical therapy (SPT) with ground gait training is well recognized to improve the motor skill in cerebral palsy (CP) disease. Confirmation is required on achieving better gross motor function with partial body weight supported treadmill training (PBWSTT). The objective of the study is to analyze combination of SPT with PBWSTT for gross motor function children with spastic diplegic CP who able to walk. A prospective design was conducted in CP patients 2-7 years of age with Gross Motor Function Classification System (GMFCS) I-III and received physical therapy 2 times per week, 20 minutes per session, a total of 20 sessions. The treatment group is continued by PBWSTT for 20 minutes per session. Gross Motor Function Measure (GMFM)-66 of walking, running, and jumping (dimension E) is measured in pre and post-physical therapy. Data were analyzed descriptively. There were 10 subjects and divided into 5 subjects in the control and the rest in the treatment group. The mean age was 48.4 months and 63.4 months respectively. The Average score of GMFM-66 dimension E pre and post-SPT were 63.54 and 65.24, the

Manuscript submitted: 9 May 2022, Manuscript revised: 18 July 2022, Accepted for publication: 27 August 2022

difference is 1.7 (2.67%) from the initial score. Standard physical therapy combined by PBWSTT score were 68.88 and 70.88, the difference is 2.00 (2.90%) from the initial score. The score after physical therapy in the treatment group was 5.64 greater than the control group. Standard physical therapy combined by PBWSTT group resulted in a higher GMFM-66-dimension E score in CP patients who able to walk.

***Keywords*---**cerebral palsy, disease, physical therapy, PBWSTT, treadmill.

Introduction

Cerebral palsy (CP) is the most common motor defect in children[1], limited activity has social impacts to patients and family[2]. Brain damage of CP results chaos and impaired development of neurological mechanisms of postural control, balance and motion. Activation of motor muscular becomes inefficient and uncoordinated due to neuromuscular and musculoskeletal disorders. Neuromuscular and musculoskeletal dysfunctions affect biomechanical difficulties that make the complexity of the problem[3].

Effective interventions in mild CP is essential for maintaining or improving motor skill[4]. It is encourage to know whether the limitations can be minimized even though the underlying disorder can not be cured[3]. Ground gait training physical therapy in CP children result no better accomplishment of motion skills, functional balance and mediolateral oscillation than treadmill exercises[5]. Johnston et al. stated the opposite that supported speed treadmill training program no significant change in flexibility, strength, motor control, Gross Motor Function Measure (GMFM) scores, and mobility[6]. Dr Soetomo hospital uses standard physical therapy (SPT) for spastic diplegic CP children with ground gait training. Therefore, confirmation is required on achieving better gross motor function with partial body weight supported treadmill training (PBWSTT).

Methods

Study design

This was prospective design that conducted from July-December 2018.

Setting

This research was performed in the Outpatient Clinic Department of Child Health and Department of Physical Medicine and *Rehabilitation, Universitas Airlangga, Dr. Soetomo Academic General Hospital, Surabaya, Indonesia.*

Study population and sampling strategy

The subjects were all children of spastic diplegic CP who able to walk and undergoing physical therapy in the hospital. Inclusion criteria were subjects with a diagnosis of spastic diplegic CP who able to walk diagnosed by neurology pediatricians, ages 2-7 years, Gross Motor Function Classification System

(GMFCS) I, II, and III[7], capable to follow a simple instruction, and parents are willing to sign an inform consent. Patients were excluded if undergone Selective Dorsal Rhizotomy (SDR) or lower extremity surgery, received botulinum toxin injection within 6 months prior the study, suffered from severe respiratory or cardiovascular disease, and uncontrolled epilepsy. Drop out criteria if withdrawing from the study, falling in critical condition or dying during study time, absence of physical therapy 3 times consecutively. Nutritional status, history of exclusive breastfeeding, anti-spasticity drugs, history of physical therapy outside of Dr Soetomo hospital, and family bounding were recorded.

Data collection and Intervention

The control group received SPT, the treatment group received SPT combined with PBWSTT. Before and after physical therapy the two groups were performed gross motor function examination blindly using a GMFM-66 dimension E test supported with Gross Motor Ability Estimator (GMAE) computer program[8]. Twenty sessions SPT and SPT combined by PBWSTT for each subject was needed. Physical therapy was performed 2 times per week, 20 minutes per session, total 20 practice sessions.by experienced physical therapists. The treatment group received treadmill according to the American Physical Therapy Association (APTA) pediatric section procedure with weight support guidelines[9]. Used Richter@ treadmill with a minimum speed 0.9 km/h, the escalation speed 0.1 km/h and supported by harness, suspension of weight support, and handrail. On the same day the treatment group after the rest of the SPT followed by PBWSTT exercise within 20 minutes per session. Completed 20 practice sessions, 1 week post intervention re-measurement GMFM-66 dimension E by the same assessor.

Data analysis

All data collected was calculated using IBM SPSS Statistics 21 software.

Ethical consideration

Ethics approval was obtained from the Ethic and Medico-legal Committee at Dr. Soetomo General Hospital Surabaya with ethic number of 222/Panke.KKE/III/2017.

Result

There were 16 subjects enrolled the study, 2 subjects were excluded because of intractable seizures and post-hospitalized with meningoencephalitis. In control group, 2 subjects were drop out after 6 sessions and 8 sessions of physical therapy because of not attending 3 sessions of physical therapy consecutively. There were 2 subjects drop out in the treatment group because of illness and not attending physical therapy more than 3 sessions consecutively. One subject was hospitalized because of cough, fever, and dypsnea (Figure 1).

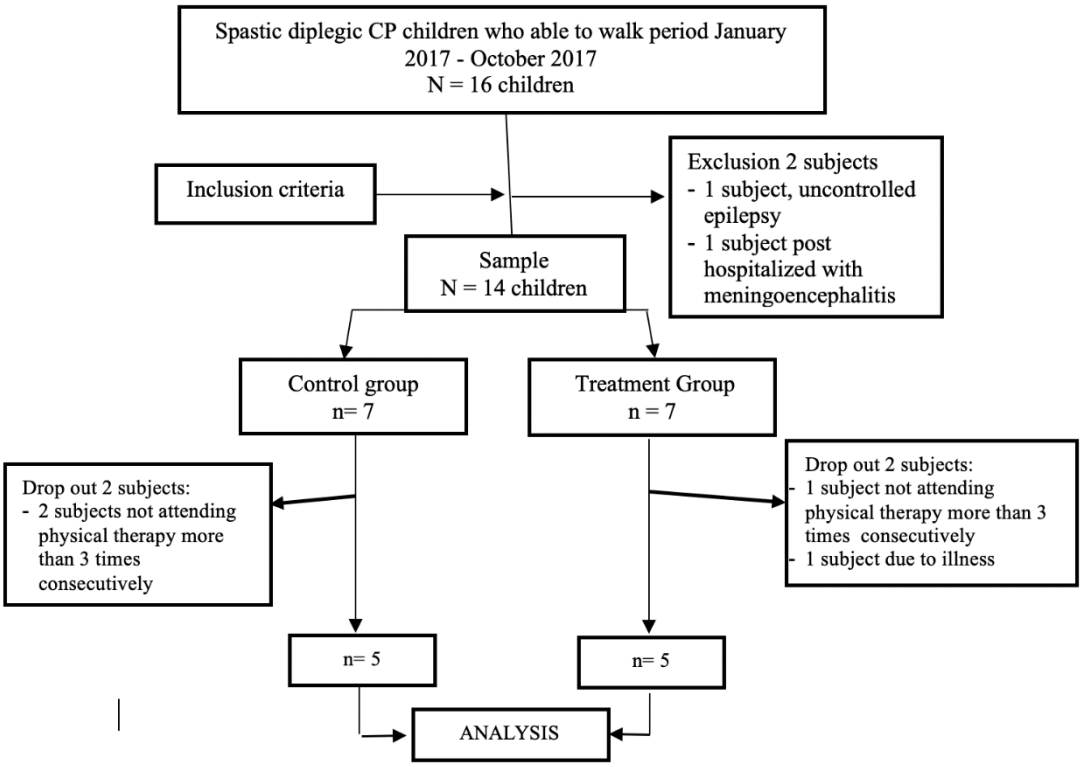

Figure 1. Diagram of research subjects

There were 10 subjects completed 20 physical therapy sessions according to the inclusion criteria. They divided into 5 children received SPT (control group) and 5 children received combination of SPT with PBWSTT (treatment group). Both groups have no experience of fatigue, physical exercise injuries, or recurrent underlying diseases such as seizures during physical therapy. The subjects were accompanied by the parents so that the children felt comfortable.

Baseline Characteristics

The baseline characteristics were differentiated by sex, age, nutritional status, history of breastfeeding, anti-spasticity drugs, other drugs consumed (phenytoin, valproate acid), physical therapy history, family bounding, and GMFCS (Table 1).

Table 1. Baseline characteristics

Characteristics	SPT (n=5)	SPT + PBWSTT (n=5)
Sex (n, %)		
• Boy	2 (40)	2 (40)
• Girl	3 (60)	3 (60)
Mean (SD) age in month	48.4 (14.22)	63.4 (16.73)
Nutritional status (n, %)		
• Good	5 (100)	2 (40)
• Moderate	0	3 (60)

• Severe	0	0
• Obesity	0	0
Breastfeeding history (n, %)		
• Exclusive breastfeeding	3 (60)	2 (40)
• Breastfeeding and formula milk	2 (40)	3 (60)
Anti-spasticity drugs (n, %)		
• Yes	0	0
• No	5 (100)	5 (100)
Other drugs consumed (n, %)		
• Phenytoin	2 (40)	0
• Valproate acid	1 (20)	1 (20)
• No drugs	2 (40)	4 (80)
Physical therapy history (n, %)		
• Currently no receiving physical therapy	4 (80)	4 (80)
• Being receiving physical therapy from outside Dr Soetomo hospital institution	0	0
• Trained own treadmill at home	0	0
• Never	1 (20)	1 (20)
Family bounding		
• Full parenting by parents	5 (100)	5 (100)
• Partial parenting	0	0
• Parenting by another family	0	0
• Live in social home	0	0
GMFCS (n, %)		
• GMFCS I	1 (20)	2 (40)
• GMFCS II	4 (80)	3 (60)
• GMFCS III	0	0

SD= Standard Deviation

GMFM-66 Dimension E Score Pre and Post SPT

The score of GMFM-66 dimension E post SPT were increase in all subjects. The smallest scores increase was 0.9 in the 28-month-old subjects in the GMFCS II category. The highest score increase was 3.1 in the 45-month-old subjects in the GMFCS II category (Table 2).

Table 2. GMFM-66 dimension E score pre and post SPT

No	Age	Sex	GMFCS	Pre			Post			Score increase
				GMFM score	SE	CI (95%)	GMFM score	SE	CI (95%)	
1.	51 mo	Boy	II	64.6	1.4	61.9 – 67.4	65.6	1.4	62.9 – 68.4	1
2.	28 mo	Girl	II	60.6	1.2	58.2 – 63.0	61.5	1.3	59.0 – 64.0	0.9
3.	68	Girl	I	70.4	1.6	67.3 – 73.5	71.7	1.6	68.5 – 74.9	1.3

	mo									
4.	45 mo	Boy	II	65	1.4	62.2 – 67.7	68.1	1.5	65.2 – 71.0	3.1
5.	48 mo	Girl	II	57.1	1.2	54.8 – 59.4	59.3	1.2	56.9 – 61.7	2.2

SE= Standard Error; CI= Confidence Interval; mo= month old

The mean score of GMFM-66 dimension E pre SPT was 63.54 and post SPT was 65.24. The mean score difference between groups was 1.7 or 2.67% from the initial score.

GMFM-66 Dimension E score Pre and Post Combination SPT with PBWSTT

The score of GMFM-66 dimension E post combination SPT with PBWSTT were increase in all subjects. The smallest scores increase was 0.9 in the 80-month-old subjects in the GMFCS I category. The greatest scores increase was 3.2 in the 80-month-old subjects in the GMFCS I category.

Table 3. GMFM-66 dimension E score pre and post combination of SPT with PBWSTT

No	Age	Sex	GMFCS	Pre			Post			Score increase
				GMFM score	SE	CI (95%)	GMFM score	SE	CI (95%)	
1.	53 mo	Girl	II	62.7	1.4	60.0 – 65.3	64.6	1.4	61.9 – 67.4	1.9
2.	80 mo	Boy	I	79.1	2.3	74.6 – 83.6	80	2.3	75.4 – 84.6	0.9
3.	80 mo	Girl	I	68.5	1.5	65.6 – 71.4	71.7	1.6	68.5 – 74.9	3.2
4.	42 mo	Boy	II	66.0	1.4	63.2 – 68.7	67.7	1.5	64.9 – 70.6	1.7
5.	62 mo	Girl	II	68.1	1.5	65.2 – 71.0	70.4	1.6	67.3 – 73.5	2.3

GMFCS=Gross Motor Function Classification System; SE= Standard Error; CI= Confidence Interval; mo=month old

The mean score of GMFM-66 dimension E pre combination SPT with PBWSTT was 68.88 and post combination SPT with PBWSTT was 70.88. The mean score difference between groups was 2.00 or 2.90% from the initial score.

Discussion

The gait development on CP is a parent's primary concern and complex issues concerning physical therapy. Although various treatments have proven effective[10,11], scientific publications show there is no systematic approach with high probabilities to produce assessable transformation in gait. This study try to find out the comparison of SPT and combination SPT with PBWSTT as an

intensive physical therapy approach by evaluating at the change in GMFM-66 dimension E score.

In this study, there was an increase in the mean score of GMFM-66 dimension E post SPT, as well as combination of SPT with PBWSTT. Similar with the meta-analysis of two investigations on the effect of treadmill versus no treadmill intervention for a GMFM percentage change, it was stated that treadmill exercise did not change the GMFM score[12].

Many factors may contribute to the results of this study. The younger the age, the brain is still very responsive to the stimuli, so with intensive physical therapy exercises increased gross motor function greater. Treadmill interventions have a practical impact on children up to age 6 years[12]. Schindl et al reported that in older CP children age of 6-18 years also achieved positive progress in GMFM and Functional Categories Measure[13]. Meanwhile, according to Mattern-Baxter, physical intervention should be given at younger than 4 years, which can produce gross motor function, walking speed, and walking resistance improvement following locomotor treadmill training[14]. Philips et al. stated that there was training-related plasticity in children with CP[15].

The nutritional status has a significant role in the physical therapy, generally spastic CP children will require a higher Recommended Dietary Allowance (RDA) for each activity. CP children age 5 to 11 year old need energy requirement 14 kcal/cm if ambulatory and 11 kcal/cm if non ambulatory[16]. There are no specific guidelines for estimating the protein needs of individuals with disabilities. The protein intake was increased to 1.5-2 g/kg/day in clinical practice for postoperative planning and wound healing with normal kidney status. The fluid requirement, many individuals of CP experience fluid loss through sialorrhoea or sweating, and can not consume sufficient fluid and/or communicate thirst. Exact weight is used to estimate fluid demand using the Holliday-Segar equation[17]. In this study we did not calculate the diet calorie of the subjects.

The varying intensity of self-employed exercise received by children at home will also be influential. The role of family at home to train the child with physical exercise continuously and intensively will affect the advancement of gross motor function. Motor learning suggests that repeated, specific task practices can increase walking activity subjects with CP[18]. Regular exercise for months or even years leads to many epigenetic adaptations in different organ systems and tissues including skeletal muscle cells, heart and brain[19,20]. Cortical plasticity, cortical representation areas have been found to be modified by sensory input, experience and learning, and in response to brain injury[21]. Enriched environments provide subjects with greater experience than normal stimulation, at the right time, to encourage significant neuroplastic change and improved functional outcomes[22].

The study found mostly in the SPT group received exclusive breastfeeding. Leventakou et al. stated that period of effective breast feeding was related with all Bayley scales except for gross motor. There is an increase in the scale of cognitive development, the scale of receptive communication, the scale of expressive communication, and the scale of fine motor development at 18 months of age irrespective of various parental and child characteristics, compared with those

who never breastfed[23]. There are many potential mechanism connecting breast milk with increased neurodevelopment during infancy. Several researches already focused on the influence of certain components of breast milk, even though it is not clear which breast milk composers are most useful in improving brain maturation. Most researchers show the function of long chain poly-unsaturated fatty acids (LC-PUFA), an important structural lipid for retinal and cerebral cortical development in early life[24]. Breast milk seems consist of hormones, phospholipids, oligosaccharides, and other trophic factors crucial for finest nerve function[25].

There was a substantial increase in the score of GMFM-66 dimension E in the combination SPT with PBWSTT compared to the SPT group. Similar with several studies, treadmill exercise is effective to improve gross motor skills in general, significant changes in walking, running and jumping (GMFM-66 dimension E)[26-28]. PBWSTT can be a viable and useful gait exercise option for children with limited ability to practice walking in conventional therapy situations[29]. The clinical impact of rehabilitation with weight support exercises can support adequate postural stability, good balance control, and less energy that facilitates efficient and safe gait[30]. Comparison of kinematics of joints showed significant differences between ground and treadmill, which showed an increase the angle of the dorso-flexion of the ankle, flexion of the knee/extension, and hip flexion, increased ankle and hip irregularities and decreased pelvic rotary deviation when walking over treadmill[31]. Treadmill exercises have a considerable effect on effective balance and mediolateral oscillation than ground walking in CP children[32].

Willoughby et al. stated that PBWSTT compared to ground walking practices for CP children found that ground walking group showed a trend of increasing the walking distance of more than 10 minutes. PBWSTT is safe and feasible in specific school environments but is no more productiveness than ground-level walking to refine the speed and durability of children with CP[33]. Matsuno et al. states that during walking on the ground, children run faster, served longer and faster steps, longer duration of a single period of attitude and swings, rather than walking on the treadmill, in any case of the use of body weight support[34]. This type of ground surface causes a significant effect on the gait form of CP children compared with weight support[34].

The limitation of the study is that the subjects were given the opportunity not to attend physical therapy for 3 consecutive times. There were many CP subjects in our country, unfortunately limited subjects fully appropriate with research requirements. Large number of samples and long physical therapy periods will give better results.

Conclusion

There was an increase score of gross motor function walking, running, and jumping according to GMFM-66 dimension E spastic diplegic CP who able to walk of pre and post-standard physical therapy also pre and post-standard physical therapy combined by PBWSTT. Standard physical therapy combined by PBWSTT

group resulted in a higher GMFM-66-dimension E score in CP patients who able to walk.

Acknowledgement
The authors thank all the resident of pediatric department for supporting the research.

Competing interest
The authors declare that no conflict of interest exist.

References

1. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, et al. A report: the definition and classification of cerebral palsy April 2006. Developmental medicine and child neurology Supplement. 2007;109:8-14.
2. Gunawan PI, Prasetyo RV, Irmawati M, Setyoningrum RA, Saharso D, Prasetyo E. Risk factor or mortality in Indonesian children with cerebral palsy. J Med Invest 2018; 65:18-20. DOI: 10.14238/sp21.6.2020.364-70
3. Gunawan PI, Saharso D. Reducing severe spasticity in cerebral palsy following meningoencephalitis by botulinum toxin. Med J Indones 2017;25:76-80. DOI: 10.13181/mji.v26i1.1297
4. Liao HF, Liu YC, Liu WY, Lin YT. Effectiveness of loaded sit-to-stand resistance exercise for children with mild spastic diplegia: a randomized clinical trial. Archives of physical medicine and rehabilitation. 2007;88(1):25-31. DOI: https://doi.org/10.1016/j.apmr.2006.10.006
5. Grecco LA, Tomita SM, Christovao TC, Pasini H, Sampaio LM, Oliveira CS. Effect of treadmill gait training on static and functional balance in children with cerebral palsy: a randomized controlled trial. Brazilian journal of physical therapy. 2013;17(1):17-23. DOI: https://doi.org/10.1590/S1413-35552012005000066
6. Johnston TE, Watson KE, Ross SA, Gates PE, Gaughan JP, Lauer RT, et al. Effects of a supported speed treadmill training exercise program on impairment and function for children with cerebral palsy. Developmental medicine and child neurology. 2011;53(8):742-50. DOI: https://doi.org/10.1111/j.1469-8749.2011.03990.x
7. Rosenbaum PL, Palisano RJ, Bartlett DJ, Galuppi BE, Russell DJ. Development of the Gross Motor Function Classification System for cerebral palsy. Developmental medicine and child neurology. 2008;50(4):249-53. DOI:https://doi.org/10.1111/j.1469-8749.2008.02045.x
8. Russell DJ, Rosenbaum PL, Wright M, Avery LM. Gross Motor Function Measure (GMFM-66 and GMFM-88) User's Manual: Wiley, 2013.
9. APTA. Body-Weight–Supported Treadmill Training: Using Evidence to Guide Physical Therapy Intervention. Section on Pediatrics, American Physical Therapy Association. Alexandria, Virginia, 2010.\
10. Purwati, Fauzi AA, Gunawan PI, Susilo I, Rini DP. The role of autologous adipose derived neural progenitor cells with cognitive and motoric function in cerebral palsy. JGPT 2019;11(1):163-9.
11. Yulianti R, Gunawan PI, Saharso D. Comparison of clinical characteristics and neuroimaging of cerebral palsy with and without epilepsy in children.

Indian J of For Med & Toxic, 2021; 15(1):1442-9. DOI: 10.37506/ijfmt.v15i1.13616
12. Valentin-Gudiol M, Bagur-Calafat C, Girabent-Farres M, Hadders-Algra M, Mattern-Baxter K, Angulo-Barroso R. Treadmill interventions with partial body weight support in children under six years of age at risk of neuromotor delay: a report of a Cochrane systematic review and meta-analysis. European journal of physical and rehabilitation medicine. 2013;49(1):67-91. Available from: https://www.researchgate.net/profile/Katrin_Mattern-Baxter/publication/236191722_Treadmill_interventions_with_partial_body_weight_support_in_children_under_six_years_of_age_at_risk_of_neuromotor_delay_A_report_of_a_Cochrane_systematic_review_and_meta-analysis/links/0f317530f736387473000000/Treadmill-interventions-with-partial-body-weight-support-in-children-under-six-years-of-age-at-risk-of-neuromotor-delay-A-report-of-a-Cochrane-systematic-review-and-meta-analysis.pdf
13. Schindl MR, Forstner C, Kern H, Hesse S. Treadmill training with partial body weight support in nonambulatory patients with cerebral palsy. Archives of physical medicine and rehabilitation. 2000;81(3):301-6. DOI: https://doi.org/10.1016/S0003-9993(00)90075-3
14. Mattern-Baxter K, Bellamy S, Mansoor JK. Effects of intensive locomotor treadmill training on young children with cerebral palsy. Pediatric physical therapy : the official publication of the Section on Pediatrics of the American Physical Therapy Association. 2009;21(4):308-18. DOI: 10.1097/PEP.0b013e3181bf53d9
15. Phillips JP, Sullivan KJ, Burtner PA, Caprihan A, Provost B, Bernitsky-Beddingfield A. Ankle dorsiflexion fMRI in children with cerebral palsy undergoing intensive body-weight-supported treadmill training: a pilot study. Developmental medicine and child neurology. 2007;49(1):39-44. DOI: https://doi.org/10.1017/S0012162207000102.x
16. Culley WJ, Middleton TO. Caloric requirements of mentally retarded children with and without motor dysfunction. The Journal of pediatrics. 1969;75(3):380-4. DOI: https://doi.org/10.1016/S0022-3476(69)80262-3
17. Scarpato E, Staiano A, Molteni M, Terrone G, Mazzocchi A, Agostoni C. Nutritional assessment and intervention in children with cerebral palsy: a practical approach. International journal of food sciences and nutrition. 2017;68(6):763-70. DOI: https://doi.org/10.1080/09637486.2017.1289502
18. Smania N, Bonetti P, Gandolfi M, Cosentino A, Waldner A, Hesse S, et al. Improved gait after repetitive locomotor training in children with cerebral palsy. American journal of physical medicine & rehabilitation. 2011;90(2):137-49. DOI: 10.1097/PHM.0b013e318201741e. PMID: 21217461
19. Hawley JA, Hargreaves M, Joyner MJ, Zierath JR. Integrative biology of exercise. Cell. 2014;159(4):738-49. DOI : https://doi.org/10.1016/j.cell.2014.10.029
20. Heinonen I, Kalliokoski KK, Hannukainen JC, Duncker DJ, Nuutila P, Knuuti J. Organ-specific physiological responses to acute physical exercise and long-term training in humans. Physiology. 2014;29(6):421-36. DOI: https://doi.org/10.1152/physiol.00067.2013
21. Plautz EJ, Barbay S, Frost SB, Friel KM, Dancause N, Zoubina EV, et al. Post-infarct cortical plasticity and behavioral recovery using concurrent

cortical stimulation and rehabilitative training: a feasibility study in primates. Neurological research. 2003;25(8):801-10. DOI: https://doi.org/10.1179/016164103771953880
22. Johansson BB. Neurorehabilitation and brain plasticity. Journal of rehabilitation medicine. 2003;35(1):1.
23. Leventakou V, Roumeliotaki T, Koutra K, Vassilaki M, Mantzouranis E, Bitsios P, et al. Breastfeeding duration and cognitive, language and motor development at 18 months of age: Rhea mother-child cohort in Crete, Greece. Journal of epidemiology and community health. 2015;69(3):232-9. DOI: http://dx.doi.org/10.1136/jech-2013-202500
24. Lauritzen L, Hansen HS, Jorgensen MH, Michaelsen KF. The essentiality of long chain n-3 fatty acids in relation to development and function of the brain and retina. Progress in lipid research. 2001;40(1-2):1-94.
25. Innis SM. Human milk: maternal dietary lipids and infant development. The Proceedings of the Nutrition Society. 2007;66(3):397-404. Available from: https://www.cambridge.org/core/journals/proceedings-of-the-nutrition-society/article/human-milk-maternal-dietary-lipids-and-infant-development/FD36C50F12B5D28EE9A6559EA1AC4E9D
26. Cherng RJ, Liu CF, Lau TW, Hong RB. Effect of treadmill training with body weight support on gait and gross motor function in children with spastic cerebral palsy. American journal of physical medicine & rehabilitation. 2007;86(7):548-55. DOI: 10.1097/PHM.0b013e31806dc302
27. Provost B, Dieruf K, Burtner PA, Phillips JP, Bernitsky-Beddingfield A, Sullivan KJ, et al. Endurance and gait in children with cerebral palsy after intensive body weight-supported treadmill training. Pediatric physical therapy : the official publication of the Section on Pediatrics of the American Physical Therapy Association. 2007;19(1):2-10. DOI: 10.1097/01.pep.0000249418.25913.a3
28. Schindl MR, Forstner C, Kern H, Hesse S. Treadmill training with partial body weight support in nonambulatory patients with cerebral palsy. Archives of physical medicine and rehabilitation. 2000;81(3):301-6. DOI: https://doi.org/10.1016/S0003-9993(00)90075-3
29. Dodd KJ, Foley S. Partial body-weight-supported treadmill training can improve walking in children with cerebral palsy: a clinical controlled trial. Developmental medicine and child neurology. 2007;49(2):101-5. DOI: https://doi.org/10.1111/j.1469-8749.2007.00101.x
30. Emara HA, El-Gohary TM, Al-Johany AA. Effect of body-weight suspension training versus treadmill training on gross motor abilities of children with spastic diplegic cerebral palsy. European journal of physical and rehabilitation medicine. 2016;52(3):356-63. Available from: https://pubmed.ncbi.nlm.nih.gov/26845668/
31. Jung T, Kim Y, Kelly LE, Abel MF. Biomechanical and perceived differences between overground and treadmill walking in children with cerebral palsy. Gait & posture. 2016;45:1-6. DOI: https://doi.org/10.1016/j.gaitpost.2015.12.004
32. Grecco LA, Tomita SM, Christovao TC, Pasini H, Sampaio LM, Oliveira CS. Effect of treadmill gait training on static and functional balance in children with cerebral palsy: a randomized controlled trial. Brazilian journal of physical therapy. 2013;17(1):17-23. DOI: https://doi.org/10.1590/S1413-35552012005000066

33. Willoughby KL, Dodd KJ, Shields N, Foley S. Efficacy of partial body weight-supported treadmill training compared with overground walking practice for children with cerebral palsy: a randomized controlled trial. Archives of physical medicine and rehabilitation. 2010;91(3):333-9. DOI: https://doi.org/10.1016/j.apmr.2009.10.029
34. Matsuno VM, Camargo MR, Palma GC, Alveno D, Barela AM. Analysis of partial body weight support during treadmill and overground walking of children with cerebral palsy. Revista brasileira de fisioterapia. 2010;14(5):404-10. DOI: https://doi.org/10.1590/S1413-35552010000500009