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Effect of intensive locomotor treadmill training on gait and endurance in ambulatory children with cerebral palsy

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Abstract
Purpose: To examine whether the shorter duration Intensive locomotor treadmill training is effective in gait and endurance along with balance and gait speed in younger ambulatory cerebral palsy (CP) children.
Methods: 12 CP children with cerebral palsy aged between 2 to 7 years and GMFCS level 1 and 2 were participated in intensive treadmill training for 5 days per week for 4 week duration after consent and ethical approval, were tested before and after protocol. Outcome measures included were GMFM- 66 (dimension D and E), Pediatric balance scale (PBS), 6 minute walk test, Energy Expenditure Index (EEI) and 10 meter walk test.
Results: Statistical analysis was done using SPSS and wilcoxon signed rank test as data were not normally distributed and Significant difference was found in all the outcome measures with $p< 0.05$.
Conclusion: Intensive locomotor treadmill training was effective in all types of CP patients and it improves gait, balance and walking speed of cerebral palsy children.

Keywords: Gross motor function, balance, ambulation, cerebral palsy children

Introduction
Cerebral palsy is a group of disorder of movement and posture causes activity limitations, which is accompanied by disturbances of sensation, cognition, communication and perception/ behaviour [1]. Children with cerebral palsy (CP) show different motor patterns than children with typical development. Their movements are defined by excessive muscle cocontraction, altered joint kinematics, and decreased postural reactions, resulting in difficulty with ambulation for 90% of these children [2]. Ambulation with or without assistance is important for various reasons. It has been shown that children who are ambulatory are more accomplished in their daily activities and peer interactions compared with children who use a wheelchair [3].
The additional benefits of walking include increased bone mineral density, cardiopulmonary endurance, and obesity prevention [4-5] Furthermore, the majority of parents of young children with CP state ambulation as an explicit goal for their child [6]. Young children with CP achieve their motor milestones at an accelerated rate compared with older children with CP [7].
In light of this, it is crucial to provide intensive physical-therapy intervention for children with CP during the earlier years of childhood. In the past 10 years, locomotor training on a treadmill (LTT) has been used in the treatment of children with CP in an attempt to maximize walking independence, gait speed, and walking endurance. Locomotor training is designed to provide task-specific training with multiple repetitions of the walking task. Active participation of the child and explicit feedback in the form of verbal and tactile reinforcement have been shown to aid in the achievement of new motor skills [8-9]. Locomotor treadmill training is one of the physical therapy intervention and it differs from Body weight supported treadmill training. Locomotor treadmill training uses very little weight support and provides maximum weight on lower limbs. It also provides task specific training with multiple repetitions [10].
Locomotor training has been studied in both ambulatory and nonambulatory children with CP, with most studies having been conducted with children ages 5 to 18 years [11-16]. Improvements in walking speed and endurance were shown in a clinically controlled study of 14 school-age children ages 5.5 to 14.7 years with moderate to severe impairments (GMFCS levels III and IV) [15].

In a study of 6 children ages 6 to 14 years with mild impairments (GMFCS level I), significant improvements were seen in the Energy Expenditure Index and gait speed [13]. When examining the effects of a 3-month LTT intervention on gross motor function in 10 school-age children from 6 to 18 years (GMFCS levels not specified), statistically significant results in Gross Motor Function Measure(GMFM) Dimensions D (standing) and E (walking, running, and jumping) were found [12]. In another group of 6 children ages 2.3 to 9.7 years with a mean age of 6.8 years and with the GMFCS levels ranging from I to V, improvement in gross motor function and endurance were found after an LTT program that was offered 3 to 4 times per week for 4 weeks [17]. In a study of 8 children ages 3.5 to 6.3 years with a mean age of 4.5 years and GMFM levels II and III, who received LTT 2 to 3 times per week for 36 weeks, significant improvements in gross motor function and stride length were found [18].

Despite these encouraging results, there is still a relative paucity of literature on LTT related to younger children with CP. The author of a recent systematic review concluded that there was a lack of evidence regarding the effects of intensive, shortterm LTT on young children with CP younger than the age of 4 years [19].

Accordingly in this study the younger CP patients of all the types were examined and assessed for balance and walking as an outcomes. The duration was kept shorter as there is less evidence in the literature for the shorter duration in treadmill training and that justifies the need of the study and the basic objective for this study is to examine the intensive locomotor treadmill training on gait and endurance in ambulatory cerebral palsy children.

Methods and materials

Approval for the study was obtained by Institutional Ethics Committee, S.B.B. College of physiotherapy, Ahmedabad. Written informed consent was taken from the parents of participants and additional verbal consent was taken from the children who were in the selection criteria and able to understand the purpose of the study. 12 cerebral palsy children were recruited from various Neuro-rehabilitation centre in Ahmedabad via purposive sampling.

Inclusion criteria included 1) All types of CP with confirmed diagnosis 2) Age 2-7 years 3) GMFCS level 1 and 2. 4) Able to walk with/without orthosis for 10 meters and *Exclusion criterias* included 1) Patients with botox and any kind of lower limb surgery within 6 months 2) Impaired cognition 3) Uncontrolled seizures 4) GMFCS level 3, 4 and 5 5) Parents who were not willing to participate.

All children were screened and assessed for baseline data and completed the protocol. The protocol for training was 30 minutes/day, 5 days/week for 4 weeks (total 20 sessions), all children were completed the training session. The position of patient and therapist was properly followed throughout training with proper safety measures. If needed very assistance was given to the patient manually by therapist like correcting foot to maintain normal biomechanics of gait. Adequate rest was provided if needed with Heart Rate monitoring throughout sessions. Speed of treadmill was kept minimum at 1.0 mph and increased gradually as per comfort of patient. The children were encouraged to walk as fast as possible.

Conventional treatment was followed simultaneously throughout study and patients were asked to maintain their normal physical activity. The treadmill training was stopped if the patient feels following symptoms: pain in the lower limb, subjective sensation of fatigue, excessive crying, shortness of breath and stiffness of leg and resumed walking when patients feels comfortable. Post intervention data was taken and analysed using SPSS 16.0 version using appropriate tests.

Outcome measures

The intervention consisted 20 sessions of intensive treadmill training with each session lasted 30 minutes. Following outcome measures were taken pre and post intervention.

1. **GMFM (Gross Motor Function Measures):** This a standardized clinical instrument, which is designed to evaluate changes in gross motor function in children with CP. The GMFM-66 version was used in the study. It has 5 dimensions: Dimension A: lying and rolling; Dimension B: sitting; Dimension C: crawling and kneeling; Dimension D: standing; Dimension E: walking, running, and jumping. GMFM has been shown to have high validity and reliability (ICC 0.98) [20]
2. **Pediatric Balance Scale (PBS):** The Pediatric Balance Scale is a modified version of the Berg Balance Scale that is used to assess functional balance skills in school-aged children. The scale consists of 14 items that are scored from 0 points (lowest function) to 4 points (highest function) with a maximum score of 56 points. Good reliability in Pediatric population [21].
3. **6 minute walk distance (6MWD):** This test is a reliable and valid measure to assess walking endurance in children with CP. The children were encouraged to walk at a self elected walking speed but were discouraged from running and were allowed to vary their pace or rest as needed. The total walking distance in meters was measured with a tape measure [22].
4. **Energy Expenditure index (EEI):** Energy Expenditure Index during outdoor walking on uneven surface is a valid, reliable and responsive outcome measure for documenting changes in walking efficiency to post-surgical interventions employed to improve walking in individuals with cerebral palsy. It determines the efficacy of movement using HR and walking speed.

$$\text{EEI} = \frac{\text{walking HR-resting HR}}{\text{walking speed}}$$
$$= \frac{\text{beats/min.-beats/min.}}{\text{meters/min.}}$$
$$= \text{beats/meter.}$$

- Normal EEI for child doing a comfortable walk: 0.48±0.15 [23].

5. **10 meter walk test:** This is a valid and reliable measure to assess walking speed in children with CP. It can be used to assess self-selected walking speed or maximum walking speed. The children walked as fast as possible without running and were timed for 10 meter. The test was performed 2 consecutive times with a short break between, and the faster time achieved was reported. The children subsequently rested until resting heart rate (HR) returned to pretest values, and then they proceeded to the 6-minute walk test [24].

Data Analysis: Nonparametric statistics were used in all analyses because of the lack of a normal population distribution. Wilcoxon signed rank test was applied for analysis.

Table 1: Demographic Distribution

Types of Cerebral Palsy	No. of children
Hemiplegic CP	4
Spastic Diplegic	4
Athetoid CP	2
Ataxic CP	2

Table 2: Mean Age of patients

No. of patients	Mean age (Years)	Standard deviation
12	4.13	2.14

The study included 12 CP patients with mean age of 4.13 years and among them 7 patients were boys and 5 patients were girls.

The results showed significant differences in Gross motor function by improving scoring of GMFM dimension D and E both with p value < 0.05 post intervention and thus improves functional walking and running abilities of a child.

Table 3: Pre and Post intervention differences in Mean and SD of all outcome measures.

Outcome measures	Pre intervention		Post intervention		Wilcoxon value	P value
	Mean	SD	Mean	SD		
GMFM D	50.20	32.66	52.34	31.91	-324	<0.01
GMFM E	43.33	31.28	44.84	31.05	-273	<0.01
PBS	23.00	22.62	25.54	21.72	-310	<0.05
EEI	2.99	1.09	1.71	0.99	-326	<0.05
6MWD	40.36	39.56	45.45	39.12	-334	<0.01
10MWT	0.95	0.34	0.33	0.74	-253	<0.05

GMFM – Gross Motor function measures
PBS- Pediatric balance scale
EEI – Energy Expenditure index
6MWD – 6 minute walking distance
10MWT – 10 meter walk test
SD – Standard deviation
p – Statistical differences

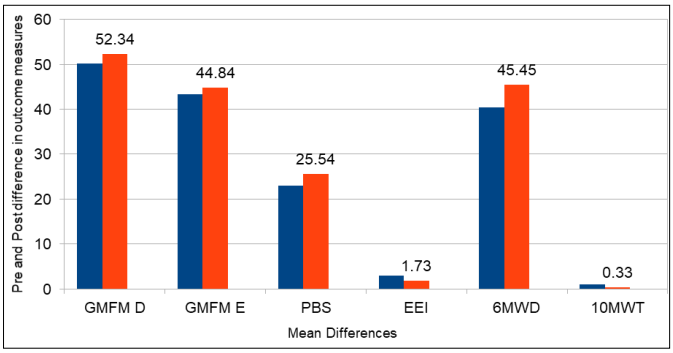

Fig 1: Mean Difference in All outcome Measures

The figure 1 shows the difference pre and post treadmill training in cerebral palsy children in all the outcome measures with statistical difference of value $p< 0.05$. That shows there is improvement in Balance, gait, Motor function and Endurance in all the types of cerebral palsy children.

Discussion

Present study shows improvement in all the outcome measures post intervention in 12 cerebral palsy children with mean age of 4.13 years. The findings of this study add to the body of knowledge that functional standing and walking skills can be improved by intensive treadmill training in children with CP. Various types of CP patients were included with different functional levels and they were able to make significant improvements in their walking ability, as measured by walking distance and gait speed. They also showed improvement in functional gross motor skills related to standing and walking. Additionally, no adverse effects such as excessive fatigue or harness discomfort from the intensive LTT training program used in this study were observed.

Previous researches has shown that stepping on a treadmill and walking may have many characteristics in common. Both the kinetics and kinematics of over ground walking and treadmill training are proven to be similar. Locomotor treadmill training offers repeated opportunities to improve balance and built strength in lower limbs. It stimulates the neuronal connections that are involved in the generation of independent walking [25]. Walking speed was increased till comfort and support was reduced as quickly as possible to maximize the independence in walking. Rest periods were eventually reduced gradually and improvement in stepping ability was observed with decreased support triggered by increase in the proprioceptive inputs from increased joint pressure throughout kinetic chain which is also supported by a study done by Lam T *et al*. (2002) [26].

The primary emphasis of this study was to enable young children with CP to take independent steps on the treadmill with as little support or facilitation as possible. This invariably led to more mistakes during LTT, and a chance for the children to self-correct before outside correction was provided. Although the children received ongoing explicit verbal feedback, tactile feedback was kept to a minimum, and the children were not corrected regarding step height or step length.

Children with CP have poor walking pattern which consumes more energy than they can generate along with poor cardiovascular condition. Walking pattern in treadmill training was improved by repetitive, rhythmical and sequencial manner of walking. Thus treadmill training also improves endurance which is proved by present study and also supported by the study which is done by Mattern Baxter *et al*. in 2009 [27].

Present study also showed significant reduction in the time taken to complete 10 meter distance and improved distance in 6 min. walk test. In contrast to other studies [28] which has done to examine the comfortable speed, the present study examined the maximum walking speed over 10 meter. The present study also shows significant improvement in balance as measured by Pediaric Balance scale (PBS). The balance and stability of a CP child is significantly affecting the walking ability of a child as well as hampers many daily activities. Impaired static and dynamic balance is connected with slower walking speed and greater physiological cost of walking. This correlation between balance and walking function was shown to be proved significantly. And that is the reason children were able to maintain balance more and that ultimately improves functional walking of a CP child which is also supported by a study [29].

Limitations

The limitations of study includes Lack of control group, smaller sample size, lack of homogenecity as the present study includes every type of CP, follow up was not taken after the post data.

Conclusion

This study provides evidence and significantly proved that intensive locomotor treadmill training was effective on gait and endurance in cerebral palsy children. Along with that it

improves the balance and reduces the energy cost of walking, thus helps to improve walking and walking speed.

Clinical implications: Treadmill training should be encouraged in all the types of CP patients to improve lower limb function.

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Conflict of interest: The authors have no conflict of interest to report.

Ethical approval: Ethical approval was obtained by Institutional Ethics Committee (IEC), S.B.B. college of physiotherapy, Ahemdabad, Gujarat. With reference no PTC/IEC/32/2013-14

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