Effect of backward walking training on balance and walking speed in children with spastic cerebral palsy: A pilot study

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Abstract

Introduction: Cerebral Palsy is defined as a non-progressive neuromotor disorder of cerebral origin. Worldwide incidence of cerebral palsy is 2-2.5/1000 birth. During walking children with spastic hemiplegic cerebral palsy often present with poor motor coordination, resulting in a short stride, increased stride frequency to maintain speed, increased swing and poor stability due to fluctuations in the center of gravity. Backward walking therapy is a safe and feasible intervention. It helps improve the poor motor function, balance and strength of lower extremity in patients with stroke, and for healthy children. Objectives: To find out the effect of backward walking training on balance and walking speed in children with spastic cerebral palsy. Method: 10 subjects were selected by inclusion and exclusion criteria and consecutively they were divided into experimental group A (backward walking training) and control group B (forward walking training). Experimental group received backward walking and control group received forward walking for 20 minutes/day for 3 days/week for 8 weeks along with conventional exercises. Outcome measures: Pre and post intervention assessment was done along with an assessment on 12th week when the intervention was not being given was done by using Pediatric Balance Scale (PBS), One Minute Walk Test (1 MWT). Results: Statistical analysis was done by using Mann Whitney, Friedmann, Repeated measures ANOVA and paired t test. Both the groups showed statistically significant improvement in balance and gait speed but between the group difference was not statistically significant. Conclusion: This study concludes that both backward walking and forward walking are equally effective in improving balance and walking speed in children with spastic cerebral palsy.

Key words: Backward walking, balance, forward walking, spastic cerebral palsy, walking speed.

Introduction:

Cerebral Palsy is defined as a non-progressive neuromotor disorder of cerebral origin. Worldwide incidence of cerebral palsy is 2-2.5/1000 birth, males have been found to have a higher prevalence of cerebral palsy than females. Cerebral Palsy is classified on basis of topographic distribution, neurologic findings and etiology and among them spastic cerebral palsy is the commonest form (65%). Depending on the distribution of spasticity it may be a spastic quadriparesis, diplegia or hemiparesis.¹
During walking children with spastic hemiplegic cerebral palsy often present with poor motor coordination, resulting in a short stride, increased stride frequency to maintain speed, increased swing and poor stability due to fluctuations in the center of gravity. Locomotor training paradigms are now commonly utilised and reported as task specific training in the lower extremity and it is reported that repetitive gait training is more effective in improving gait speed, stride length and joint kinematics than traditional physical training in cerebral palsy children.

Various modalities are used in the treatment of children with cerebral palsy which includes conventional physical therapy, sensory integration, hippotherapy, aquatic therapy, functional resistance training, task specific training, etc. Recently, therapists have also started using backward walking training as a part of physical rehabilitation in the treatment of children with cerebral palsy but its results have to be studied widely to support it. At a given speed, when compared with forward walking, backward walking elicits more electromyographic activity which in turn results in higher physiological cost and greater perceived exertion.

Backward walking therapy is a safe and feasible intervention. It helps improve the poor motor function, balance and strength of lower extremity in patients with stroke, and for healthy children, especially in balance and motor control ability. A study by Yang et al found that a program of backward walking in parallel bars significantly increased speed, step length and stride length in a group of individuals, with hemiparesis as a result of stroke. Concentric muscle activity in forward walking would become eccentric activity in backward walking and vice versa. According to the task specific approach, practising the walking itself is the best way to improve the walking pattern. Forward walking provides an increased opportunity to train the entire gait cycle, facilitating an enhanced gait pattern in children with cerebral palsy.

Currently there is no established optimal protocol for gait training as an intervention in children and young adults with CP, with limited comparison between gait training methods in the literature. At a given speed, when compared with forward walking, backward walking elicits more electromyographic activity which in turn results in higher physiological cost and greater perceived exertion. Unlike forward gait, backward gait has no heel contact during the early stance phase; consequently, it might minimize stress to the lower limb joints by avoiding rapid weight load during the early phase. In addition, motor units are recruited more effectively, and adequate stress is provided to the lower limb joints, increasing the strength and balance ability of muscles near the knee joints. Backward walking training provides an intensive way for motor learning programme to improve walking performance. Motor learning training describes ways in which motor patterns can be acquired and modified through experiential learning. Backward walking can help to oppose and unlearn triple flexion posture of lower limb i.e. (hip and knee flexion along with ankle dorsiflexion).

Traditional forward walking does not provide enough of a stimulus to either build or tone muscle because it doesn't ever overload the muscle fibers. Incorporating steps or hills into forward walking training may provide a temporary overloading stimulus that can
cause some muscle development. But the muscle size increases are likely to plateau rather quickly, because your muscles will adapt to stress after a short time.10,11

Therapists use backward walking on a treadmill or over ground to rehabilitate patients for sports or functional mobility. However, there is a lack of work done to investigate the effect of backward walking training on functional performances in children with spastic cerebral palsy. So, the aim of this study was to assess the effect of backward walking training on balance and walking speed in children with spastic cerebral palsy through a comparative analysis with forward walking training, and determine whether the effects last after the interruption of the interventions.

**Materials and Methodology:** After obtaining ethical clearance from institutional ethical committee. 10 children who fulfilled the inclusion and exclusion criteria were included in the study. Written informed consent from the parents/caretakers was taken after explaining purpose of the study in their language. The procedure, benefits and potential risk of study were explained to them. This study was conducted on 10 children with spastic cerebral palsy from different setups including a tertiary hospital, orphanage and rehabilitation centers in and around Pimpri-Chinchwad, Pune. Inclusion criteria included children with spastic cerebral palsy aged 6-12 years, GMFCS level 1 or 2, spasticity grade 1, 1+, 2 according to Modified Ashworth Scale, ability to walk 10 meters forward or backward with or without assistive device, those who were able to understand and follow commands. Baseline measurement of the eligible children for pediatric balance scale and one minute walk test were taken.12 They were consecutively assigned to backward walking training group (n=5) and forward walking training group (n=5).

Children in Group A received backward walking training and those in group B received forward walking training along with conventional exercises which were given in both the groups. In group A, backward walking training was given for 20 minutes, on alternate days for 8 weeks. Similarly in group B, forward walking training was given for 20 minutes, on alternate days for 8 weeks. The conventional exercises included general ROM exercises for bilateral upper and lower limbs as a warm up for the patients before walking, stretching of the tight muscles and weight shifts. Conventional exercises were followed by forward/ backward walking training respectively.

Initially for backward walking training group i.e. group A the children were asked to take a step backwards with assistance as required. The therapist used to walk behind the child so that he may be able to hold the child at times of imbalance to prevent falls. The therapist used to give auditory commands to the child to lift the legs appropriately, to stop and turn and to keep walking. Intervention was given to each group separately for 20 minutes/day for 3 days/week for 8 weeks. After the completion of intervention i.e at 8 weeks and at 12 weeks the readings for outcome measures was taken. During this period no intervention was given to the children.
Data Analysis And Interpretation:
The normality of data was checked by using Shapiro-Francis Test. Statistical analysis for PBS, 1 MWT was done by using friedmann, repeated measures ANOVA, unpaired t test and Mann whitney test.

**Graph 1:** Mean value of pediatric balance scale score in both the groups

**Interpretation:** This graph shows that there is statistically significant increase in the mean value of pediatric balance scale from baseline to post intervention with p<0.05 in both the groups. However the difference between the groups is statistically not significant (p>0.06).

**Graph 2:** Mean value of distance in one minute walk test in both the groups.
Interpretation: This graph indicates that there is significant increase in mean value of one minute walk test from baseline to post intervention and slight decrease in the carryover effect (i.e. 4 weeks post intervention) with $p<0.05$ in both the groups. However the difference between the groups is statistically not significant ($p>0.06$).

Result:

1. **Pediatric Balance Scale:**
   For experimental group A (Backward walking training group), PBS mean values at baseline, post intervention and 4 weeks after post intervention (carryover) showed statistically significant improvements in balance with $p <0.05$ which is shown in Graph 1. This indicates that backward walking training was effective in improving balance for children with spastic cerebral palsy. For control group B (Forward walking training group), pediatric balance scale mean values showed statistically significant improvements in balance with $p<0.05$ which is shown in Graph 1. This indicates that forward walking training was also effective in improving balance for children with spastic cerebral palsy. Intergroup comparison of PBS, the difference of pre and post values as well as pre and carryover values of both the groups were analysed which showed non-significant difference between the groups $p>0.05$. This indicates that both the groups were equally effective in improving balance but there was no statistically significant difference between the groups.

2. **One Minute Walk Test**
   For experimental group A (Backward walking training group), 1MWT mean values at baseline, post intervention and 4 weeks after post intervention (carryover) showed statistically significant improvements in the distance covered with $p <0.05$ which is shown in Graph 2. This indicates that backward walking training was effective in improving gait speed for children with spastic cerebral palsy. For control group B (Forward walking training group), 1MWT mean values showed statistically significant improvements in the distance covered with $p <0.05$ which is shown in Graph 2. This indicates that forward walking training was also effective in improving gait speed for children with spastic cerebral palsy. Intergroup comparison of one minute walk test, the difference of pre and post values as well as pre and carryover values of both the groups were analysed which showed non-significant difference between the groups $p>0.05$. This indicates that both the groups were equally effective in improving the gait speed but there was no statistically significant difference between the groups.

Discussion:
Cerebral palsy majorly affects the functional performances of these children which includes components like balance and walking speed. This study was done on 10 subjects diagnosed with spastic cerebral palsy having GMFCS level 1 and 2 and ability to walk 10 meters forward/backward were included and their data were analysed. The experimental group (Backward walking training group) and control group (Forward walking training group) had 5 subjects each. Experimental group A underwent conventional exercises followed by backward walking for 20 minutes. Control group B underwent conventional
exercises followed by forward walking for 20 minutes. All the subjects were assessed with pediatric balance scale and one minute walk test at 0, 8 and 12 weeks.

Major focus of this study was to see the effect of backward walking training on balance and walking speed in children with spastic cerebral palsy. There were improvements in the pediatric balance scale scores and one minute walk test after backward walking training. According to Westcott there are three primary systems which are responsible for the balancing process which includes: 1. the sensory system (visual, cutaneous & proprioceptive, and vestibular senses) 2. Motor system 3. the biomechanical/musculoskeletal system which includes the muscles, bones and joint frame. All these systems are thought to be associated with an improvement in balance by backward walking training.²

Backward walking is more difficult and demanding than forward walking due to postural instability and no visual cue to progress. Studies suggest that backward walking can result in greater muscle and neural activities, higher heart rate, oxygen consumption and lower patellofemoral joint reaction forces. Hackney and Earhart demonstrated that backward direction generally had more impact on people with Parkinson’s disease than a secondary cognitive task, i.e. mental arithmetic task, during walking.¹³

Van Deursen et al have outlined that both forward and backward walking are mediated by the same central pattern generator, and only small modifications in the central pattern generator are required to produce the different characteristics of each walking mode.⁹ This suggests that both backward walking training and forward walking training might show similar results in children with spastic cerebral palsy. This was similar to the findings of our study as both backward walking and forward walking training were almost equally effective in improving the balance, gait speed and lower limb functional strength in children with spastic cerebral palsy.

Although on the other hand, some previous studies have also shown an increase in the oxygenated haemoglobin in the supplementary motor area, precentral gyrus and superior parietal lobule when participants walked backwards rather than forwards. This suggests more of a stability challenge in backward walking training as compared to forward walking training. Hao and Chen have found in a study on a healthy 16 year old child that backward walking training improved the balancing ability.²

This study has also reported improvement in the walking speed which is supported by Hooper et al who reported that patient’s balance and proprioception improves because of backward walking training. Also the hip, knee and ankle stabilizers get conditioned. This increase in speed of walking is also related to the increase in lower limb activity thereby leading to improvement in the activity of lower limb muscles so the patient can move at a faster pace. Greater balance and proprioception also helps to move faster as the body is more supported.¹⁴

Eek et al have reported that muscle strength training in children with cerebral palsy improved the muscle strength and gait function.² Backward walking training have also
been found to increase quadriceps strength. Kramer and Reid et al have compared the physiological and mechanical advantages of backward walking training with forward walking. They reported that during backward walking muscles of the legs remain active for longer duration. Overall in this study both backward walking training and forward walking training were equally effective in improving the balance and gait speed in children with spastic cerebral palsy.

**Conclusion:**
This study concludes that both backward walking training and forward walking training are equally effective in improving balance and walking speed in children with spastic cerebral palsy.

**Limitations & Recommendations:**

**Limitations:**
1. Small sample size.
2. Individual muscle strength was not assessed.

**Recommendations:**
1. This study can be carried out on a large sample size.
2. Individual muscle strength can be assessed.
3. Electromyographic activities of the muscles can be recorded and assessed.

**Conflict of interest:**
There was no conflict of interest found in this study.

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**References:**


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