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IMPACT OF BODY WEIGHT SUPPORTED BACKWARD TREADMILL TRAINING ON WALKING SPEED IN CHILDREN WITH SPASTIC DIPLEGIA

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ABSTRACT

Background: A lot of the ambulating children with spastic diplegia were able to walk with flexed hips, knees and ankles this gait pattern is known as crouch gait. The most needed functional achievement of diplegic children habilitation is to be able to walk appropriately. The development of an independent and efficient walking is one of the main objectives for children with cerebral palsy especially those with spastic diplegia.

Method: Twenty children with spastic diplegia enrolled in this study, they were classified into two groups of equal number, eligibility to our study were ages ranged from seven to ten years, were able to ambulate, They had gait problems and abnormal gait kinematics. The control group (A) received selected physical therapy program based on neurodevelopmental approach for such cases, while the study group (B) received partial body weight supported backward treadmill training in addition to regular exercise program. Gait pattern was assessed using the Biodex Gait Trainer II for each group pre and post three months of the treatment program.

Results: There was statistically significant improvement in walking speed in the study group ($P < 0.05$) with significant difference when comparing post treatment results between groups ($p < 0.05$).

Conclusion: These findings suggested that partial body weight supported backward treadmill training can be included as a supplementary therapeutic modality to improve walking speed and functional abilities of children with diplegic cerebral palsy.

Keywords: Diplegia, Backward, Treadmill, walking speed, Cerebral Palsy, Body Weight Support.

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INTRODUCTION

Spastic diplegia is amongst the most widely recognized clinical subtypes of cerebral palsy. It represents about 44% of the total occurrence of CP. It is used when the motor impairment is milder in the upper limbs than the lower limbs. Most children have major weakness in the trunk and hypertonic limbs [1].

Spastic diplegia is characterized by increased muscle tone with difficulty in relaxing. Active movements are slow and stiff with abnormal patterns. Lower limbs are more affected than upper limbs. Head and neck are unaffected but there is weakness and limited rotation of the trunk [2].

Different ways of locomotion have been accounted in walking diplegic children. These motor behaviors are characterized by limited mobility in their lumbar spine, pelvis, and hip joints and show limited asymmetric pelvic tilt or pelvic rotation during gait. Many of these children walk with flexed hips, knees and ankles this gait pattern, known as crouch gait. Crouch gait is due to increased activity or tightness of the hamstrings [3]. Walking even with assistance in children with CP is needed for contribution in daily living activities and for their physical development. Proportionate to children who use wheelchair, walking children with CP are more skilled in their daily living activities in addition to dealing with normal children. As well, muscle action and weight acceptance during walking augment bone mass and can decrease the possibility of hip subluxation or dislocation. Other gains from ambulation are increased cardiopulmonary fitness and obesity prevention [4].

Biodex medical systems are an innovative product that are designed to provide health care givers by modalities to assess and treat patients especially those having neurological disorders affecting their balance and locomotion abilities and also provide health care professionals with equipments that help in providing an exercises programs for such cases. These products include Biodex gait trainer that assess gait and locomotor abilities and also provides different exercises to improve gait and Biodex unweighing system that provides opportunity to train neurological patients in an open access gait training especially with treadmill to improve locomotion in neurologic patients and children with cerebral palsy [5].

Treadmill training with partial body weight support (PBWS) allows proper and whole walking movement, through trunk stability. This allows proper weight shift, loading of the more affected limb and proper action of the antigravity muscles. As well, the right muscular model can be trained constantly and proficiently [6].

Therefore, the purpose of this study was to detect the impact of body weight supported backward treadmill training in addition to regular exercise program on walking speed in children with diplegic cerebral palsy.

SUBJECTS, MATERIALS AND METHODS

This randomized controlled study was applied to detect the impact of backward body weight supported treadmill training in addition to regular exercise program on walking speed in children having spastic diplegia.

For this purpose, twenty children with spastic diplegia from both gender were selected from out-patient clinic, Faculty of Physical Therapy, Cairo University. Having the following criteria; Their ages ranged from seven to ten years, were able to ambulate, They had gait problems. (Level II or III GMFCS), had no convulsions, had no history of surgical interference in the last 6 months, Their heights were 1 meter and more to be able to see the screen and they had abnormal gait kinematics which can be collected from assessment of gait kinematics by Biodex Gait Trainer IITM. Children who had any fixed contractures or convulsions were excluded from this study.

They were divided into 2 groups, group A (received the regular therapeutic exercise program according to neurodevelopmental approach for such cases) and group B (received the regular therapeutic exercise program for such cases along with 15 min backward treadmill walking with partial body weight support (30% relief of total body weight) using Biodex unweighing equipment).

To assess walking speed for the children participated in this study, The Biodex Gait Trainer 2TM is an equipment used to evaluate and provide training of walking in patients with gait disorders. (Biodex Medical INC., Shirley, New York, USA).

All children were evaluated prior and after three-months of training. For evaluation of gait parameters, each child was permitted to try the gait trainer set up before recording his gait parameters.

For treatment, Biodex unweighing system was used to diminish the amount of weight bearing of a patient (partial weight bearing) and grant appropriate erect posture through providing single point suspension this occurs through the suspension part of this system that can accommodate children and adult. The unweighing system can be used during forward and backward gait training.

Children were asked to walk backward with suspension held on the treadmill with body weight support (30% body weight release) with speed of 0.01 m/sec. and 0 degree inclination for 5 min. firstly increased gradually to reach 2m/sec. for total time of session 15 min., totally. Partial body weight supported backward treadmill training was conducted once a day, 3 sessions a week for 3 months [7].

The protocol of the study was approved from the ethics committee, Faculty of Physical Therapy, Cairo University. Following an explanation of the experimental protocol and written consents were obtained from all participants and their parents.

For data analysis, all statistical measures were performed through the Statistical Package for Social Studies (SPSS) version 17 for windows, (SPSS, Inc., Chicago, IL). Paired and Un paired T test were performed to detect level of significance within and between groups respectively.

RESULTS

This study was conducted to examine the efficacy of unweighing system during backward treadmill training besides the physical therapy program on gait pattern in diplegic cerebral palsied children.

There were two independent variables, the first one was

the (tested groups); between subjects factor which had two groups (Group A received the regular therapeutic exercise program given for such cases while Group B received the same regular exercise program for such cases and 15 min backward treadmill training with partial body weight support).

The second one was the (training periods); within subject factor which had two levels (pre, post). In addition, this test involved a dependent variable (walking speed).

Twenty spastic diplegic children from both sexes enrolled in the study. They were classified into two groups. Group (A) consisted of 10 participants (4 boys and 6 girls), their mean \pm SD for age, weight, and height of 7.42 ± 0.97 years, 23.64 ± 3.86 kg, and 109.66 ± 8.66 cm respectively, and Group (B) consisted of 10 participants (3 boys and 7 girls), their mean \pm SD for age, weight, and height of 8.35 ± 1.72 years, 24.15 ± 3.58 kg, and 106.66 ± 8.66 cm respectively. T test was conducted to compare between groups for the demographic data (age, weight and height) which revealed no significant differences between groups for age ($p = 0.154$), weight ($p = 0.763$) and height ($p = 0.449$). The descriptive statistics and t-test for the demographic data are presented in table (1) and Figure (1).

Table 1: Participants' demographic data for the groups (A and B)

Item	Group A	Group B	MD	T value	p- value
	$\bar{X} \pm SD$	$\bar{X} \pm SD$			
Age (Years)	7.42 ± 0.97	8.35 ± 1.72	0.93	1.489	0.154
Weight (kg)	23.64 ± 3.86	24.15 ± 3.58	0.51	0.306	0.763
Height (cm)	109.66 ± 8.66	106.66 ± 8.66	3.00	0.775	0.449

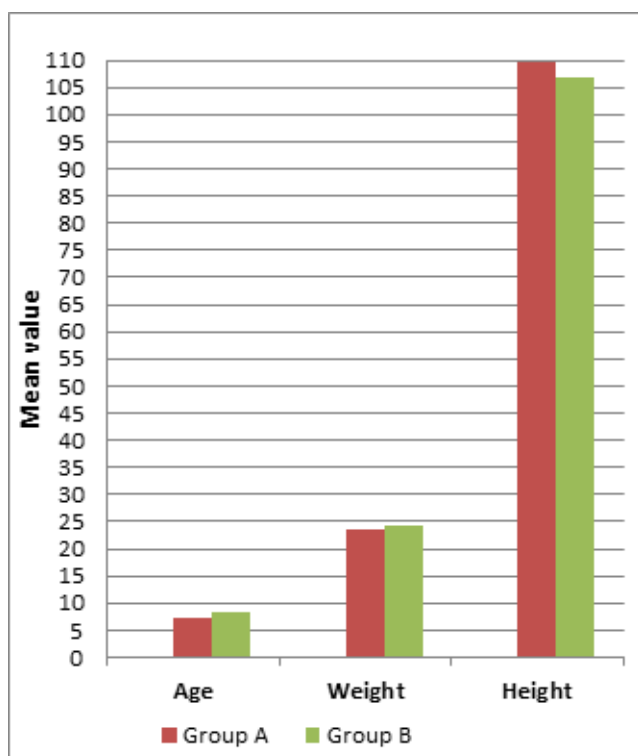


Figure 1: Demographic data for the groups (A and B).

Data presented in table (2) and illustrated in figure (2) showed that, in group A, the pre and post treatment mean values \pm SD of walking speed were 0.29 ± 0.15 and 0.31 ± 0.14 (Meter/Sec) respectively that indicated no significant difference ($P > 0.05$).

Data presented in table (2) and illustrated in figure (2) showed that, in group B, the pre and post treatment mean values \pm SD of walking speed were 0.32 ± 0.16 and 0.597 ± 0.12 (Meter/Sec) respectively. The difference between the pre and post treatment mean values \pm SD of walking speed was significant ($P = 0.0004$). The percentage of change was 86.5% which indicated post treatment improvement.

As presented in table (2) and illustrated in figure (2), when comparing the pre treatment mean values of both groups (A and B), concerning walking speed, the mean values \pm SD were 0.29 ± 0.15 and 0.32 ± 0.16 (Meter/Sec) for both groups correspondingly that indicated no significant difference ($P < 0.05$).

Also, it's presented in table (2) and illustrated in figure (2), when comparing the post treatment mean values of both groups (A and B), concerning walking speed, the mean values \pm SD were 0.31 ± 0.14 and 0.597 ± 0.12 (Meter/Sec) for both groups respectively, The difference between both groups in their post treatment mean values \pm SD of walking speed was significant ($P = 0.0001$).

Table 2: Pre and post treatment mean values of walking speed in both groups (A and B):

Walking speed (Meter/Sec)	Means \pm SD	Means \pm SD	MD	% of change	T value	P- value
	Pre test	Post test				
Group A	0.29 ± 0.15	0.31 ± 0.14	0.018	6.2	0.31	0.59
Group B	0.32 ± 0.16	0.597 ± 0.12	0.277	86.5	4.38	0.0004*
MD	0.03	0.287				
T value	0.433	4.92				
P-value	0.67	0.0001*				

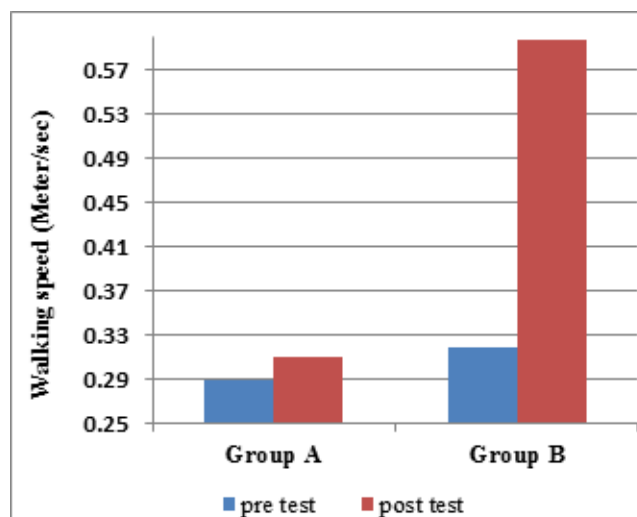


Figure 2: Pre and post treatment mean values of walking speed (Meter/sec) in both groups (A and B)

DISCUSSION

This study was conducted to inspect the impact of body weight supported backward treadmill training besides regular exercise program on walking speed in children having spastic diplegia. This study enrolled spastic diplegic type of cerebral palsy, that represents the main population of spastic types. This finding was confirmed by Yokoshi, 2012 [3] who stated that spastic diplegia is the main frequent type of CP accounting for about 44% of CP and about 80% of premature infants.

Observation of the pre-treatment mean values of this study revealed that these children had gait abnormalities as crouch walking and slow walking speed. These findings were consistent with Carr and shepherd, 2008[8], who reported that, the dynamic postural control while walking was affected in diplegic children due to the following: 1- Lack of specific muscle control. 2- Abnormal muscle tone. 3- Relative muscular imbalance around joints, 4- poor equilibrium reactions. 5- reliance on primitive reflexes for ambulation.

Observation of the pre-treatment mean values of this study confirmed the findings of Sanger et al., (2010) [9] who reported that the spastic diplegic children have difficulties while walking due to poor muscle control in the arms and legs. Protective reactions of catching themselves when falling are impaired. Keeping and relocating the center of gravity (COG) within the base of support (BOS) in response to outside disturbances or voluntary movements is impaired. Dynamic balance is required for daily life activities as walking, running, stair climbing, and sports. Dynamic activities move the COG between boundaries of the BOS and sometimes outside the BOS.

Also, these children have walking abnormalities due to inadequate weight shifting while walking. This come in agreement with Andrew et al., (2009) [10] who stated that, defective weight acceptance, single limb stance of limb progression is also resultant of impairments in strength and motor control induced by neurological insult occurring in diplegic cerebral palsy.

The abnormal motor behavior while walking may be due to tonal affection and presence of abnormal pattern of movement caused by absence of cortical control. These results were supported by Niam et al., (2009) [11] who reported that, patients with diplegia have abnormal tone in their muscles, defective movement control, incoordination, loss of anticipatory postural control, diminished cutaneous sensation, distorted proprioception of lower limbs' joints and abnormal vestibular mechanism that may affect their ability to maintain standing and walking balance.

The most needed functional achievement of diplegic children habilitation is to be able to walk. Possibility, security or amount can be provided by the equipments that often used to enhance gait training. The selection of a specific equipment is directed by the therapeutic goals (e.g., improve muscles strength, enhance reciprocal muscle activation, or proper muscle activity during walking) and by the child's functional capabilities as well [12].

Post- treatment considerable improvement of the study

group may be due to the impact of the suspension system on maintaining proper body alignment with the least expenditure of muscle energy and postural tone. The suspension system enabled the trained children to maintain head, trunk and pelvis in an upright position that means more effective postural control resulting in more efficient gait pattern. These findings came in agreement with Anderson et al., 2009 [13] who reported that positioning and equipment may be used as adjuncts to handling.

Backward walking improves proprioception and balance. This has a role in increasing speed of walking as when the patient becomes balanced so this will also give him greater support to move faster. This is supported by Hooper et al., 2004 [14] who reported that backward walking improves the patient's balance and proprioception and will act to condition hip, knee and ankle stabilizers. This increase at the speed of walking is related also to the increase at lower limb activity that occurs with backward walking as when the activity of lower limb muscles is improved so the patient can move at faster speed.

The improvement in speed of walking can be also attributed to that the mechanical and neural responses to backward walking were based on two primary modifications: a reduction in hip movement which probably increases stability by minimizing the anterior-posterior displacement of the center of gravity, and a shorter absolute swing / stance duration.

This is supported by the findings of Bobath, 1990 [15] who reported that hip extension with knee flexion that occurs during backward walking acts to break the extensor synergy of diplegic patients and also the movements of knee flexion with extension were constantly trained in backward walking training and may develop neuro-motor control for children with diplegia with synergy influence in the lower limbs.

This comes in agreement with Begnoche et al., 2013 [16] who reported the partial body weight support system may help a wide range of impaired patients as they regain walking function, it is a suitable modality to use whenever gait therapy is prescribed, for those who are unable to hold their own weight and those lacking strength to support themselves during the assisted walking. Besides aiding gait pattern reduction, partial weight bearing therapy help patients to perform cardiovascular workouts in conjunction with a treadmill, enhance balance and improve posture.

The locomotion of diplegic patients is often impaired by poor muscular activation, poor weight bearing capacities and poor balance as many of gait deviations seen in diplegic patients. So, in rehabilitation of diplegic children, we used treadmill training and backward gait training with the suspension frame to address these *problems* (Rose et al., 2012 [17]).

The justification for this approach is that while partial body weight support reduces the biomechanical and equilibrium constraints of full weight bearing, walking movements may be trained on the treadmill through the activation of spinal and supraspinal locomotion centers (Visintin et al., 2011) [18].

So, combination between suspension and backward treadmill training enhance walking abilities in children with cerebral palsy due to double impact of gained balance and proper positioning of different body segments achieved by suspension system along with improving proprioception, lower limb stabilization and lower limb muscle strength gained by backward treadmill training, resulting in faster walking speed in children with diplegic cerebral palsy.

Finally, in the case of walking training in children with CP, considerations regarding the circumstances imposed to these children and facilitating a more efficient and secured learning environment of locomotion training. And most significantly, one should recognize whether the different forms of training augment or obstruct the transfer of learning to the child's every day framework. So, studies similar to this one are essential because they compare the walking training in diverse directions to prove the impact of each procedure on the ability of locomotion, and so on the day by day contexts in children with CP.

CONCLUSION

From the obtained results of this study, it can be concluded that partial body weight supported backward treadmill training is an effective modality that can be used to improve walking abilities and speed of walking in children with spastic diplegia.

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