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Original Research Article

FORWARD VERSUS BACKWARD BODY WEIGHT SUPPORTED TREADMILL TRAINING ON STEP SYMMETRY IN CHILDREN WITH SPASTIC DIPLEGIA

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ABSTRACT

Background: The development of an independent and efficient walking is one of the major targets for children with cerebral palsy especially those with spastic diplegia.

Objective: To compare the efficacy of forward versus backward body weight supported treadmill training in addition to regular exercise program on step symmetry in children with spastic diplegia.

Materials and Methods: Twenty children with spastic diplegia from both sexes participated in this study, they were classified into two groups of equal number; the first study group (A) received partial body weight supported backward treadmill training in addition to regular exercise program, while the second study group (B) received partial body weight supported forward treadmill training in addition to regular exercise program. Gait pattern was assessed using the Biodex Gait Trainer II for both groups before and after three months of the treatment program.

Results: The results of this study revealed statistically significant improvement ($P<0.05$) in the measured variable for both groups with no differences between groups.

Conclusion: These findings suggested that partial body weight supported treadmill training can be used during forward and backward gait training while it's better to be used with backward gait training as an additional therapeutic modality to improve step symmetry and functional abilities of diplegic children.

KEY WORDS: Body Weight Support, Treadmill, step symmetry, Diplegia.

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INTRODUCTION

Spastic diplegia is the common term applied to variation of spastic quadriparesis in awhich the lower limbs are more affected than upper limbs. It accounts for approximately 50% of total CP population [1].

In spastic diplegic children, muscle stiffness is predominantly in the legs and less severely affects the arms and face, although the hands may be clumsy. Tightness in certain leg muscles makes the leg move like the arms of a scissor. Children with this type of CP may require a walker or leg braces. Intelligence and language skills are usually normal [2].

Among those individuals with locomotor impairment, one group that can benefit from walking training with BWS is children withcerebral palsy, since the development of an independent and efficient walking is one of the major targets for this group [3].

Ambulation with or without assistance in children with CP is important for participation in activities of daily living (ADL) and for their physical development. Compared with children who ambulate in a wheelchair, ambulatory children with CP are more accomplished in their activities of daily living as well as interactions with typically developing peers. In addition, muscle activity and weight bearing during walking increase bone mineral density and can decrease the risk of hip subluxation or dislocation. Other beneûts gained from ambulation are increased cardiopulmonary endurance and obesity prevention [4].

Systems involving the use of a suspension vest and partial body weight support (BWS) have been used as a form of walking training. In this type of training, subjects practice treadmill walking while their weight is partially supported by a suspension vest. The BWS can be used in different ways that allow various degrees of body motion. The height of the vest and the subject's body weight can be adjusted by the calibration of load cells, counterweights, pneumatic lift, springs, etc. Thus, the system may support a percentage of the subject's body weight (partial BWS) or the total body weight, according to the examiner's wish [5].

The Biodex Gait Trainer 2TM was used to provide gait training and also to evaluate gait parameters pre- and post-treatment including: average step length (m), walking speed (m/sec), time on each foot (recorded as a percent of gait cycle), and ambulation index [6].

MATERIALS AND METHODS

This randomized controlled study was applied to compare the efficacy of forward versus backward body weight supported treadmill training in addition to regular exercise program on step symmetry in children with spastic diplegia. For this purpose, twenty children with spastic diplegia from both sexes were selected from out- patient clinic, Faculty of Physical Therapy, Cairo University. Having the following criteria; their ages ranged from eight to eleven years, were able to ambulate, they had gait problems. (Level II or III According to Gross Motor Function Classification System (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 II TM.. 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 for such cases along with 15 min backward treadmill training with partial body weight support using Biodex unweighing system) and group B (received the regular therapeutic exercise program for such cases along with 15 min forward treadmill walking with partial body weight support (30% relief of total body weight) using Biodex unweighing system).

To assess time on each foot or step symmetry for the children participated in this study, The Biodex Gait Trainer 2TM is a device used to assess and train walking performance in patients with neurologic gait dysfunctions. It is composed of a treadmill with an instrumented deck that monitors and records kinematic gait parameters including: step length, walking speed and step symmetry. A high resolution color touch screen LCD display, attached to the treadmill, to control the device settings. Moreover, the Biodex Gait Trainer 2TM is supplied by a serial interface which allows download of patient data to a computer for archiving, reporting or exporting data. (BiodexMedical INC., Shirley, New York, USA).

All children (in both groups) were evaluated prior to the commencement of baseline training and at the end of the three-month training period (post-treatment). For evaluation of gait parameters, each child was first allowed to be familiar with the gait trainer set up before recording the gait parameters. This was achieved through instructing the child to walk over the gait trainer and to follow the tread belt movement for three to five minutes. This might be repeated two or three times till the child became adapted with the apparatus. For treatment, Biodex unweighing system or the suspension system was used to reduce the amount of weight born by a patient (partial weight bearing) and provide proper upright 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 with harness secured on the motor driven treadmill with body weight support (30% relief of total body weight) 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. The treadmill training with partial body weight support is conducted once a day, 3 times /week for 3 months [7].

The protocol of this study was approved by 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 or families.

For data analysis, all statistical measures were performed through the Statistical Package for Social Studies (SPSS) version 17 for windows, (SPSS, Inc., Chicago, IL). Prior to final analysis, data were screened for normality assumption, homogeneity of variance, and presence of extreme scores. This exploration was done as a pre-requisite for parametric calculations of the analysis of difference. Paired and Un paired T test were performed to detect level of significance within and between groups (A and B) respectively.

RESULTS

The present study was conducted to compare the effect of unweighing system during treadmill training versus over ground walking in addition to the physical therapy program on gait pattern in diplegic cerebral palsied children.

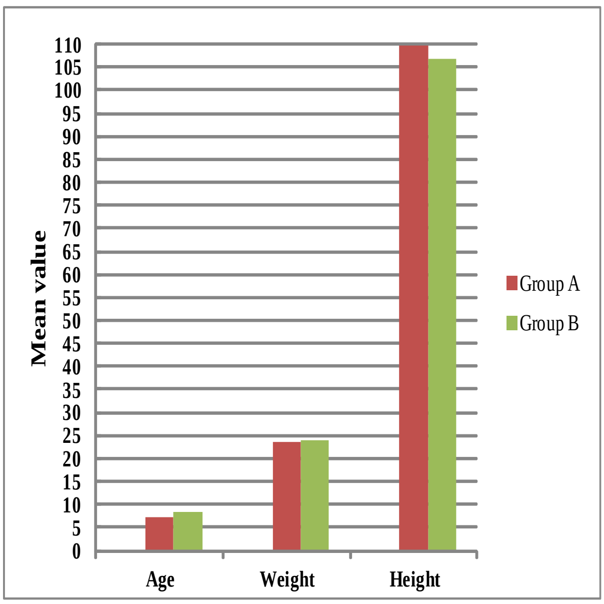
There were two independent variables, the first one was the (tested groups); between subjects factor which had two groups (Group A received the regular therapeutic exercise program given for such cases and 15 min over ground walking with partial body weight support while Group B received the same regular therapeutic exercise program given to such cases and 15 min 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 variables (time on each foot).

Twenty spastic diplegic children from both sexes participated in the study. They were classified into two groups; (group A, B). Group (A) consisted of 10 participants (4 boys and 6 girls), their mean ± 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 boy and 7 girls), their mean ± 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 that there were 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 participants' demographic data for all groups are presented in table (1) and Fig (1).

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

Item	Group B	Group C	MD	T value	p-value
	$\bar{X}$±SD	$\bar{X}$±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	0.775	0.449

Fig. 1: Demographic data for the groups (A, B and C).



Data presented in table (2) and illustrated in figure (2) showed that, in group A, the pre and post treatment mean values ± SD of time on the right lower limb were 74.67±18.5 and 53.33±3.1 (% of gait cycle) respectively. The difference between the pre and post treatment mean values ± SD of time on the right lower limb was significant (P= 0.001). The percentage of change was 28.57% which indicated post treatment improvement.

Data presented in table (2) and illustrated in figure (2) showed that, in group B, the pre and post treatment mean values ± SD of time on the right lower limb were 69.67±16.85 and 56.33±4.76 (% of gait cycle) respectively. The difference between the pre and post treatment mean values ± SD of time on the right lower limb was significant (P= 0.024). The percentage of change was 19.15% 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 time on the right lower limb, the mean values ± SD were 74.67±18.5 and 69.67±16.85 (% of gait cycle) for both groups respectively which 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 time on the right lower limb, the mean values ± SD were 53.33±3.1 and 56.33±4.76 (% of gait cycle) for both groups respectively which indicated no significant difference (P < 0.05).

Table 2: Pre and post treatment mean values of time on the right lower limb in both groups (A and B):

Time on the right lower limb	Means ± SD	Means ± SD	MD	% of change	T value	P- value
	Pre test	Post test				
Group A	74.67±18.5	53.33±3.1	21.34	28.57	3.59	0.001*
Group B	69.67±16.85	56.33±4.76	13.34	19.15	2.41	0.024*
MD	5	3				
T value	0.6319	1.67				
P-value	0.53	0.11				

***Significant level is set at alpha level <0.05**.

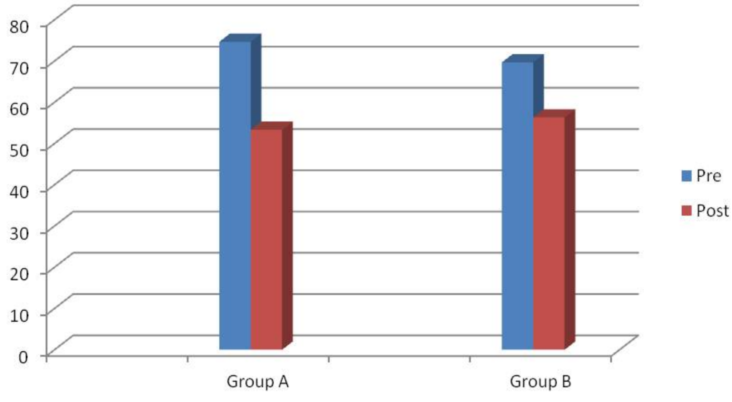


Fig. 2: Pre and post treatment mean values of time on the right lower limb in both groups (A and B).

Data presented in table (3) and illustrated in figure (3) showed that, in group A, the pre and post treatment mean values ± SD of time on the left lower limb were 27.0±18.71and 46.67±3.1 (% of gait cycle) respectively. The difference between the pre and post treatment mean values ± SD of time on the right lower limb was significant (P= 0.003). The percentage of change was 72.85% which indicated post treatment improvement.

Data presented in table (3) and illustrated in figure (3) showed that, in group B, the pre and post treatment mean values ± SD of time on the left lower limb were 30.33±16.85 and 43.67±4.67 (% of gait cycle) respectively. The difference between the pre and post treatment mean values ± SD of time on the right lower limb was significant (P= 0.024). The percentage of change was 43.98% which indicated post treatment improvement.

As presented in table (3) and illustrated in figure (3), when comparing the pre treatment mean values of both groups (A and B), concerning time on the left lower limb, the mean values ± SD were 27.0±18.71 and 30.33±16.85 (% of gait cycle) for both groups respectively which indicated no significant difference (P < 0.05). Also, it's presented in table (3) and illustrated in figure (3), when comparing the post treatment mean values of both groups (A and B), concerning time on the left lower limb, the mean values ± SD were 46.67±3.1 and 43.67±4.67 (% of gait cycle) for both groups respectively which indicated no significant difference (P < 0.05).

Table 3: Pre and post treatment mean values of time on the left lower limb in both groups (B and C).

Time on the left lower limb	Means ± SD Pre test	Means ± SD Post test	MD	% of change	T value	P- value
Group A	27.0±18.71	46.67±3.1	19.67	72.85	3.28	**0.003***
Group B	30.33±16.85	43.67±4.67	13.34	43.98	2.41	**0.024***
MD	3.33	3				
T value	0.418	1.69				
P-value	0.68	0.11				

***Significant level is set at alpha level <0.05**.

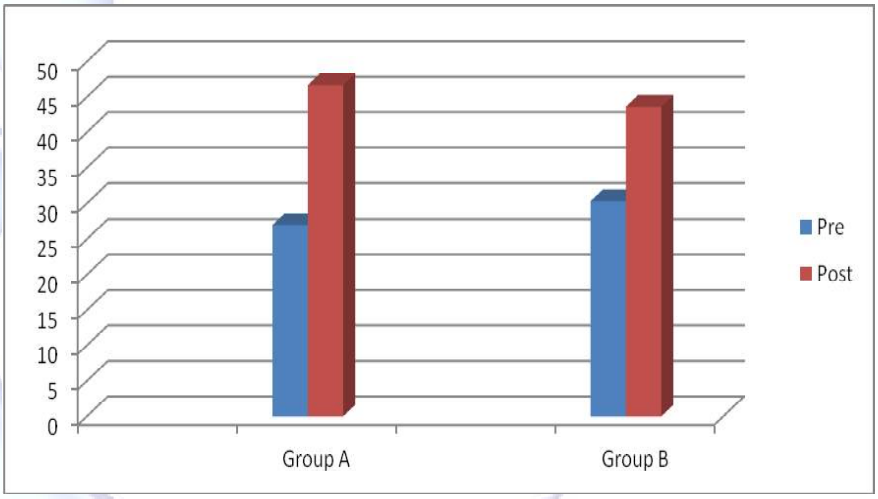


Fig. 3: Pre and post treatment mean values of time on the left lower limb in both groups (A and B).

DISCUSSION

This study was conducted to compare the efficacy of forward versus backward body weight supported treadmill training in addition to regular exercise program on step symmetry in children with spastic diplegia. The present study included spastic diplegic type of cerebral palsy, that constitutes a major classification among spastic types. This finding was reported by Christian Thorogood [8] who stated that spastic diplegia accounts about nearly one-third of all spastic cerebral palsied cases as a result of unilateral brain lesion.

Observation of the pre-treatment mean values of this study confirmed the findings of Sanger et al.,[9] who reported that the child with spastic diplegia has difficulty while walking because of poor muscle control in the arms and legs. Protective responses of catching oneself when falling are impaired. The maintain and regain the center of gravity (COG) within the base of support (BOS) in response to outside perturbations or voluntary movements is impaired.

The pre treatment results may be due to abnormal motor control in children with spastic diplegia. These results were confirmed by Carr and shepherd[10], who reported that, the dynamic postural control while walking was impaired in diplegic children due to the following: 1- Loss of selective muscle control. 2- Abnormal muscle tone. 3- Relative imbalance between muscle agonists and antagonists across joints, 4- Deficient equilibrium reactions. 5- Dependence on primitive reflex patterns for ambulation.

Significant improvement obtained in the post-treatment mean values of the measured variable of the study groups may be also attributed to the effect 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 confirm the findings of Anderson et al.[11]who stated that positioning and equipment may be used as adjuncts to handling.

Better gait symmetry or developing adequate time on each foot in the study groups may be attributed to the use of the suspension system which provided more stabilization to the child and minimized the displacement of COG under each foot, so keeping the center of gravity (COG) near the middle also it helped the child to "keep small amplitude of COG motion and decrease postural sway, which reflected a good balance control during treadmill training.

The significant improvement obtained in the post-treatment mean values of the measured variable especially for the first study group may be attributed to the effect of backward gait training with partial body weight suspension. This comes in agreement with Chen et al.[12] who stated that, walking backwards on the treadmill works muscles in an entirely different way than walking forwards .By walking backwards on the treadmill (especially on an incline) engage the quadriceps muscles and calves to a great extent.

Backward walking acts to improve 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 [13].

Both forward walking and backward walking are mediated by the same central pattern generator (CPG), and only small modifications in the CPG are required in order to produce the different characteristics of each walking mode. The reorganization of the muscle synergies or neuro-motor control in lower limbs during backward walking might be a possible reason for the improvement of balance by backward walking exercise resulting in more step symmetry while walking [14].

The improvement in the measured parameters 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 [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 isolated movements of knee alternating flexion with extension were repeatedly practiced in backward walking training and may contribute to improve neuro-motor control for patients with diplegia with synergy influence in the lower extremities.

Finally, in the case of walking training in children with CP, one should be concerned with the conditions imposed to these children and should work for enabling a more effective learning from this form of locomotion. And perhaps most importantly, one should understand whether the different types of training facilitate or hinder the transfer of learning to the child's daily context. Thus, studies like the present one are important because they compare the walking training in different directions to verify the impact of each procedure on the ability of locomotion, and consequently on the activities of daily living in children with CP.

This study had some limitations that need to be acknowledged, such as the small sample size.

CONCLUSION

The results of this study indicate that Biodex unweighing system can be used during forward and backward gait training to improve step symmetry in children with spastic diplegia while it's more effective when used during backward gait training.

Conflicts of interest: None

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