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# Effect of Treadmill Training with Partial Weight Bearing on Functional Abilities in Hemiparetic Cerebral Palsied Children

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## ABSTRACT

**Purpose:** To evaluate dynamic postural control in spastic hemiparetic cerebral palsied children following the participation in a physical therapy program including treadmill training with partial body weight support (30% relief of total body weight) using the suspension system in addition to a specially designed exercise program. **Subjects and Methods:** Thirty spastic hemiparetic children, 8-10 years old participated in this study. The children were classified randomly into two equal groups; control and study groups. Stability index (SI) was assessed by using the Biodex stability system Peabody Developmental Motor Scale (PDMS-2) was used to assess motor control before treatment and after three-month treatment program. The control group received treadmill training with full weight bearing without using the suspension system in addition to the therapeutic exercise program. The study group received treadmill training with the suspension system for partial body weight support in addition to the same therapeutic exercise program. **Results:** The overall, mediolateral and anteroposterior stability indices decrease significantly after treatment in the two studied groups. The locomotive subtest of PDMS-2 of the two studied groups increased significantly after treatment. The Three Stability Indices and PDMS-2 score were compared between the two groups before treatment. After treatment, the study group showed significantly lower stability indices and significantly higher PDMS-2 score. **Conclusion:** Postural stability and balance required for gait in spastic hemiparetic children can be improved by treadmill training with partial and full weight bearing.

**Key words:** Postural Control, functional abilities, Cerebral Palsy, Hemiplegia, Treadmill, Suspension System.

## INTRODUCTION

Cerebral palsy defined as a non-progressive, non-hereditary lesion of the cerebral cortex resulting in postural and motion disturbances. Children with cerebral palsy may exhibit inaccurate sequencing and timing of muscle activation، abnormalities of agonist-antagonist muscle control، insufficient balance, and insufficient production of muscular force[1].

During hemiplegic walking, there are deficits in balance, proprioception and selective control that limit their ability to shift and support body weight on the paretic limb. Decreases in velocity, cadence and stride length occur with relative increase in gait cycle duration and initial and double limb support periods. Marked asymmetries are evident between the paretic and uninvolved limbs in stance and swing times, single limb support, and stance-to-swing ratio[2].

Postural control involves controlling the body's position in space for the dual purposes of stability and orientation. Postural stability or balance is the ability to maintain the projected center of mass "COM" within the limits of base of support "BOS". Whereas postural orientation is the ability to maintain an appropriate relationship between the body segments and between the body and the environment for a task[3].

Hemiplegic children have deficits in the selection of appropriate sensory inputs for postural control. Since the accurate interpretation of sensory cues from the environment is necessary for effective motor planning to occur, thus deficits in sensory processing and integration are expected to affect the acquisition of mature postural control and mature patterns of movement necessary for motor milestone acquisition[4].

Balance is a complex motor skill often referred to as postural control. Postural control is the ability to maintain equilibrium in a gravitational field by keeping or returning the center of body mass over the base of support. In addition, it included the ability to control the body position in space. Balance has been viewed as a prerequisite for functional competence because it is vital to the performance of activity of daily living. Good balance is necessary to perform activities with great force, with great speed or in a great amount[5].

Patients with hemiplegia develop abnormal muscle tone, abnormal movement control, incoordination within motor strategies, loss of anticipatory postural control, reduced cutaneous sensation, distorted proprioception of lower limbs and impaired visual and abnormal vestibular mechanism that may affect their ability to maintain standing and walking balance[6].

Postural control disorders seen in hemiparetic patients related to asymmetric weight bearing as patients with hemiparesis support most of their body weight by using their uninvolved lower extremity. This asymmetric weight bearing contributes to gait abnormalities[7]. Gait impairment or the inability to walk or walking with abnormal pattern constitute a major challenge to professionals engaged in the rehabilitation of walking disabilities[8].

Treadmill training with partial body weight support (BWS) enables correct and entire walking movement through stabilizing the trunk. This enables a correct weight transfer, loading of the affected limb and selective activity of the antigravity muscles. Also, the correct muscular pattern can be trained consistently and efficiently[9].

The present study was conducted to investigate the effect of treadmill training with suspension (partial weight bearing) and without suspension (full weight bearing) in addition to the physical therapy program on dynamic postural control in hemiparetic cerebral palsied children.

## SUBJECTS AND METHODS

This study included 30 spastic hemiparetic cerebral palsied children selected from the outpatient clinic of the Faculty of Physical Therapy, Cairo University. They were 16 males and 14 females. Nineteen children had right and 11 had left side affection. The inclusion criteria were; age 8-10 years, spasticity grade 1 to 2 according to modified Ashworth scale[10], balance problems (frequent falling especially when increasing speed or walking on uneven surface) confirmed by balance assessment on the Biodex stability system, ability to stand unassisted and ability to follow simple verbal commands and instructions. Exclusion criteria were visual, auditory, perceptual deficits, structural deformities of lower limb, surgical operations of the lower limbs and epilepsy. The sample was divided randomly into two equal groups; control group and study group.

### Evaluation Process:

All patients were subjected to evaluation of degree of spasticity according to the modified Asworth scale[10]. The Biodex stability system (Biodex medical system, Shirley, NY, USA) was used for the assessment of the dynamic postural control. All patients were evaluated before starting the study and after three months of treatment. Two different balance tests of the Biodex stability system were used: dynamic balance and dynamic limits of stability tests. The test duration was two minutes. The result of the test was reported as three indices: overall stability index (SI), mediolateral (SI) and anteroposterior (SI). The mean of three consecutive measures of SI was calculated. Peabody Developmental Motor Scale (PDMS-2) was used for determining gross and fine motor skills, skills that are not completely developed and the plan of the instructional program to develop those skills.

### Treatment Plan

The control group received a specially-designed physical therapy exercise program in addition to gait training on treadmill with full weight bearing without using a suspension system. Each child was asked to walk on the motor-driven treadmill for 30 minutes with a speed of 0.01 m/sec and 0 degree inclination for the first 10 minutes increased gradually to reach 2.25 m/sec and 10 degrees inclination for the last 20 minutes of the session. The session was divided into three periods of activity followed by a rest period in between. Treadmill training was conducted three times/week for three successive months[11].

The study group received the same exercise program received by the control group in addition to gait training on treadmill with partial body weight support (30% relief of total body weight). This amount of body weight relief was chosen based on previous studies, reported that partial body weight support of > 30% was not advisable because of a significant reduction of activity of relevant weight-bearing on muscles in the affected lower limbs of hemiparetic subjects[12]. Weight bearing support was mechanically applied in a modified parachute harness supported centrally by a set of pulleys connected to a flexible spring. The harness supports the patients primarily about the pelvis, lower abdomen and chest to avoid interfering with lower limb movement.

### The Designed Exercise Program

- The program was directed towards inhibiting abnormal muscle tone and abnormal postural reflexes and facilitating normal patterns of postural control.
- Slow, regular and rhythmic proprioceptive training for the upper and lower limbs and trunk to control spasticity and stimulate joint mechanoreceptors.
- Training of active trunk extension for improving postural control and balance.
- Weight shift exercises from kneeling, half-kneeling and standing on a mat and tilting board for training of pelvic stability and equal weight shift on both sides with concentration on the affected side.
- Exercises applied on the balance board from sitting, standing and walking, tilting done from different positions in forward, backward and sideways to facilitate righting and equilibrium reactions to improve the postural mechanisms.
- Enhancement of protective reactions through application of quick and large amplitude of stimulus to train saving reactions. This enhances the child to take protective reactions (forward, backward and sideways) to regain balance from different positions when child pushed forward, backward and sideways.

### Statistical analysis

Data was analyzed using IBM SPSS Advanced Statistics version 22.0 (SPSS Inc., Chicago, IL). Two-way analysis was not used due to factor-group interaction. For quantitative data, comparison between two groups was done using Mann-Whitney test. Comparison of repeated measures was done using Wilcoxon signed-ranks test. A p-value < 0.05 was considered significant.

## RESULTS

Table (1) shows general characteristics of the two studied groups. The two groups were comparable in age (P = 0.805), height (P = 0.652) and weight (P = 0.917).

***Table (1): Descriptive data of both study and control groups.***

| | Study Group (n = 15) | | Control Group (n = 15) | | p value |
|---|---|---|---|---|---|
| | Mean ±SD | Range | Mean ±SD | Range | |
| Age (years) | 8.3±1.1 | 7-10 | 8.4±1.1 | 7-10 | 0.805 |
| Height (cm) | 126.3±4.5 | 118-134 | 127.0±3.9 | 120-132 | 0.652 |
| Weight (kg) | 30.0±2.8 | 26-34 | 30.1±2.4 | 26-33 | 0.917 |

Table (2) shows the results of dynamic balance testing at stability level 8 in the two studied groups before and after treatment. The three stability indices decrease significantly after treatment in the two studied groups. The locomotive subtest of PDMS-2 scale of the two studied groups before and after treatment was shown in table 2. It increased significantly after treatment in the two groups. The three SI indices and PDMS-2 score were comparable between the two groups before treatment. After treatment, the study group showed significantly lower stability indices and significantly higher PDMS-2 score.

***Table (2): Stability indices and locomotive subtest of PDMS-2 scale before and after treatment in the two studied groups.***

| | | Study Group (n = 15) | Control Group (n = 15) | p value |
|---|---|---|---|---|
| Overall SI | Pre | 3.04±0.40 | 3.08±0.37 | 0.778 |
| | Post | 1.76±0.35 | 2.51±0.33 | < 0.001 |
| | p value* | < 0.001 | < 0.001 | |
| Anteroposterior SI | Pre | 2.57±0.22 | 2.45±0.19 | 0.121 |
| | Post | 1.34±0.15 | 1.10±0.21 | 0.001 |
| | p value* | < 0.001 | < 0.001 | |
| Mediolateral SI | Pre | 1.94±0.19 | 1.95±0.17 | 0.880 |
| | Post | 1.01±0.25 | 1.46±0.22 | < 0.001 |
| | p value* | < 0.001 | < 0.001 | |
| locomotive subtest of PDMS-2 | Pre | 71.8±1.23 | 70.8±1.8 | 0.087 |
| | Post | 96.9±2.18 | 90.3±3.9 | < 0.001 |
| | p value* | < 0.001 | < 0.001 | |

* repeated measures comparison

## DISCUSSION

The present study demonstrated that treadmill training with suspension was superior to that without suspension for dynamic postural control in hemiparetic cerebral palsied children. It resulted in significantly lower stability indices in addition to higher score on the Peabody Developmental Motor Scale.

Before treatment, results of both groups showed disturbed stability evidenced by low overall directional control and long time needed to complete the test. These results are consistent with those reported by Roncesvalles et al.,[13] who found high stability indices indicating a lot of movements during the Biodex test and therefore impaired balance control in children with cerebral palsy.

Postural control disorders in hemiparetic patients were related to asymmetric weight bearing as patients with hemiparesis support most of their body weight by using their uninvolved lower extremity. This asymmetric weight bearing contributes to gait abnormalities[14].

Post-treatment improvement of SI can be attributed to the effect of the exercise program which was directed towards inhibiting the abnormal muscle tone and abnormal postural reflexes, facilitating normal patterns of postural control (righting and equilibrium reactions) and developing a greater variety of normal movement patterns particularly in the trunk and lower extremities. These exercises involved the antigravity mechanisms, postural reactions components, weight bearing on the affected side, and symmetrical weight shift on both legs. On the other hand, walking on the treadmill can forces hip extension and ankle dorsiflexion in support phase. With increasing the speed of the treadmill, the relatively strong stretch applied to the hip flexor and calf muscles at the end of stance may enhance muscle activity for swing[15].

Post-treatment improvement goes in agreement with Laufer et al.,[16] who suggested that treadmill training may be more effective than conventional gait training for improving

some gait parameters as functional ambulation, stride length, percentage of paretic single stance period and gastrocnemius muscular activity.

Superiority of improvement in the study group can be attributed to the effect of partial weight bearing therapy. By removing partial weight of motor impaired individuals, rehabilitation is achieved in a safe, effective manner with minimal stress across the weight bearing joints (ankles, knees, hips and back). Use of unloading, i.e. controlled reduction of body weight, while performing task-specific activities has the potential for broad applications in rehabilitation[17].

Treadmill training with partial body weight suspension helped the hemiparetic children to organize sensory information from the visual, somatosensory and vestibular systems (sensory strategies) for postural control, thus creating internal neural representation necessary for coordinated postural abilities[18].

This task-specific approach enables patients with repetitive practice of complex gait cycles instead of single-limb gait preparatory maneuvers. Patients walk more symmetrically with less spasticity and better cardiovascular efficiency on the treadmill than with floor walking. Partial weight bearing with treadmill training relieves the strenuous effort of the therapists and provides control of the trunk in a phase-dependent manner is a new technical alternative for gait training of hemiplegic patients[18].

## CONCLUSION

We can conclude that partial to full weight bearing in combination with treadmill training is a safe and effective strategy to improve postural stability and balance required for gait in spastic hemiparetic children. During this approach, the hemiparetic patients can practice the complete gait cycle i.e. support, balance and stepping. The suspension system eliminates the need to use adaptive movements that favor a symmetrical gait. Speed of the treadmill can be increased, thereby stimulating the patient to walk faster.

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## الملخص العربي

# تأثير التدريب على السير المتحرك مع التحميل الجزئي لوزن الجسم في حالات الخدل الشقي الطولي التقلصي عند الأطفال

**الهدف من البحث:** تقييم فاعلية التدريب على المشي باستخدام سير الجري المتحرك مع التعليق الجزئي لوزن الجسم بنسبة تعليق 30% من وزن الجسم بالإضافة إلى برنامج التمرينات العلاجية على التحكم في القوام أثناء الحركة عند الأطفال المصابين بالشلل النصفي الطولي التقلصى . **مواد البحث وأساليبه:** تم إجراء هذا البحث على ثلاثين طفلا من الأطفال المصابين بالشلل النصفي الطولي التقلصى من الجنسين تتراوح أعمارهم من ثمانية إلى عشرة سنوات وقد تم تقسيمهم إلى مجموعتين متساويتين. المجموعة الأولى (المجموعة الضابطة) تحتوى هذه المجموعة على 15 طفلا وقد تلقت هذه المجموعة برنامجا مكون من التدريب على المشي باستخدام سير الجري المتحرك دون أي تعليق لوزن الجسم بالإضافة إلى مجموعة من التمرينات العلاجية المختارة. أما المجموعة الثانية (مجموعة الدراسة) فتحتوى على 15 طفلا (8 أولادا و 7 بناتا) وقد تم وضع برنامج علاجي بالتدريب على المشي باستخدام سير الجري المتحرك مع التعليق الجزئي للجسم بنسبة تعليق30% من وزن الجسم بالإضافة إلى نفس مجموعة التمرينات العلاجية التي تلقتها المجموعة الضابطة. وقد تم قياس معاملات الاتزان للمجموعتين باستخدام جهاز البيودكس (معامل الثبات الكلى – معامل الثبات الأمامي الخلفي – معمل الثبات الجانبي) وقد أخذت هذه القياسات للمجموعتين قبل وبعد ثلاثة شهور من تطبيق العلاج . **النتائج :** أظهرت النتائج وجود فروق ذات دلالة إحصائية عالية للمجموعتين عند مقارنة نتائج ما قبل العلاج بنتائج ما بعد العلاج. وكانت نتائج الدراسة هي وجود تحسن ملحوظ في كلتا المجموعتين ولكن مع وجود فروق ذات دلالة إحصائية لصالح مجموعة الدراسة عند مقارنة نتائج ما بعد العلاج للمجموعتين. **التوصيات :** وفقا للنتائج السابقة نوصى بإضافة البرنامج المستخدم في البحث وهو التدريب على المشي باستخدام سير الجري المتحرك مع التعليق الجزئي لوزن الجسم للبرنامج التأهيلى لحالات الأطفال المصابين بالشلل النصفي الطولي التقلصى وذلك لما له من تأثير واضح في تحسين التحكم في القوام والمحافظة على الاتزان أثناء الحركة عند هؤلاء الأطفال .

**الكلمات الدالة :** (التحكم في القوام ، الاتزان ، الشلل المخى ، الشلل النصفي الطولي التقلصى ، سير الجري المتحرك ، التعليق الجزئي للجسم) .