EFFECT OF BODY WEIGHT SUPPORTE TREADMILLTRAINING ON GAIT PARAMETERS IN SPASTIC HEMIPLEGIC CHILDREN

Reda S. M. Sarhan,
**PTD in physical therapy for pediatrics and pediatrics Surgery,* Department of Physical Therapy and Rehabilitation, Al-Hussein University Hospital, Al-Azhar University .

Abstract:

Background and purpose. This study was done to assess the effect of a treadmill training program with partial body weight support on gait parameters in hemiplegics cerebral palsied children. **Subjects.** The study included twenty six patients from both sexes, with age ranged from 9 to 15 years of age (Mean age10.5,SD=2.8) (14 males and 10 females), the mean height and weight were 1.45m (SD=0.14) and 37.38Kg (SD=13.66), respectively. They were recruited from schools, clinics and hospitals in Shoubra, Cairo area. according to certain criteria. **Methods**. Patients were divided randomly into two equal groups, study group and control group. The control group was exposed to the traditional method of treatment for gait training only. The study group received a program of body weight support treadmill gait training in addition to the traditional method of treatment for gait training, Treatment for both groups continued for 12 successive weeks, 3 times per week. Evaluation was performed before and after the suggested period of treatment, Utilizing gait evaluation parameters, including step length (st/cm.), stride length (str/cm.), cadence (Cs/min.), Velocity (Vcm/sec.) and the Bruininks-Oseretsky Test Motor Proficiency Subtest 2 for balance. **Results.** The results at the end of the treatment period showed highly significant difference between the control and the study groups ($p<0.001$).in stride length, cadence recorded a high significant difference between both groups and, gait velocity and balance. The comparison test between the control group and the study groups reported a highly significant difference in all measured parameters ($p<0.001$). **Conclusion.** This study demonstrated that body supported treadmill training is an effective and safe measure in improving gait parameters of spastic hemiplegics children.

Key words. Gait parameters. Treadmill training. Hemiplegics cerebral palsied.

Introduction

Cerebral palsy is the commonly used term to describe a developmental disability condition, with a range of dysfunction, dependent on the location and extent of damage to the developing brain [(1)]**.** It is a neurological condition that affects movement and muscle coordination. It is caused by damage to brain before, during or shortly after birth. Children may show signs of slow motor development, weak muscle tone, problems with fine motor tasks and difficulty walking or keeping balance.[2]

Seventy percent of cases occur before birth (congenital cerebral palsy) and are caused by a disruption in the normal development of a part of the brain. Infection during pregnancy and poor oxygen supply to the fetus are possible causes of congenital cerebral palsy. In many cases, the cause is unknown. About 20 percent of children acquire cerebral palsy from birth complications, like asphyxia during labor and delivery. Ten percent of cases are acquired shortly after birth from some type of damage to the infant brain, like brain infection or head trauma.[3]

There are three main types of cerebral palsy. Children who have signs of more than one type are said to have a mixed form of the condition. Spastic cerebral palsy is the most common form of the condition, affecting 70 to 80 percent of patients. The muscles are stiff, tight and contracted (causing the limb to permanently bend). One or both sides of the body may be affected. Athetoid, or dyskinetic cerebral palsy, occurs in 10 to 20 percent of patients. It affects the entire body and is characterized by changes in muscle tone and abnormally slow, writhing movements of the hands, arms, feet or legs. The movements may increase during periods of stress and decrease during sleep. If the muscles of the face are involved, patients may have problems with speech or drooling. Ataxic cerebral palsy is the rarest form of the condition, affecting 5 to 10 percent of patients. It generally affects balance and coordination, causing an unsteady gait, poor coordination, tremor and problems with fine motor skills[4].

Disabilities associated with CP may be mild, moderate, or severe.
In individuals with severe CP, especially those with cognitive impairment. The impairment of voluntary control is the hallmark of cerebral palsy [1,5]. Many hemiplegics cerebral palsy patients suffer from residual neuromuscular disabilities. The ability to walk is a major concern for children with cerebral palsy and improving or maintaining the stability is often considered to be the primary focus of most therapeutic interventions[6] . Walking is the most common form of exercises, and for many patient it may be the first step in their reconditioning [7,8] concluded that loss of unilateral lower limb control has a major impact on the mobility of the patient. The primary effects of the lower limb paralysis are the unsafe and impaired walking ability, resulting from poor unilateral ankle and knee control. They emphasized the inadequate motor control of the lower extremity, particularly the anti-gravity muscles, as a major contribution to a decrease in the patient's functional level.

The mean goal of physical therapy is to assist cerebral palsied patients in returning to a more functional and efficient gait. with this goal in mind, many therapy techniques have been developed including, proprioceptive neuromuscular facilitation (PNF)[8], Bobath Neuron-developmental therapy (NDT),sensory integration (SI), and Brunnstorm movement therapy, all of which have benefits and drawbacks to their use. While research has demonstrated improvements in gait using these methods, no form of intervention has been found to be clearly superior to the other[1] .

Recently, one technique that has shown promise is body weight support treadmill training (BWSTT). This therapy technique uses a harness and lifts to support the patient over a moving treadmill, and is a logical progression of the decreased weight bearing. In BWSTT patients are able to walk without loading all their weight through their lower extremities [9]. The BWS equipment provides the support needed to assume an upright position and allows the limb to move forward in stepping motion. There have been numerous studies on adults with hemiplegia and spinal cord injuries on the effectiveness of body weight supported treadmill training, (BWSTT) [10]. Adult studies have hypothesized that partial BWSTT works in the adult population due to the presence of a central pattern generator. A central pattern generator, in response to a stimulus, causes neural linkages in the spinal cord to generate the rhythmical motor acivity necessary for gait[11] .

There is limited scientific evidence that supports the use of BWSTT, NMES and many other treatment modalities to improve strength, endurance and functional mobility in children with CP. Unfortunately, none of these modalities have been clearly established as effective in scientifically rigorous, well-controlled clinical trials[12].

In particular, the use of task-specific training such as BWSTT, has shown great promise in helping stroke and motor incomplete spinal cord injured patients regain some walking ability. In addition, BWSTT has shown promise in helping to correct the gait and improve functional ambulation in children with CP. In a non-randomized study of 10 children with CP, some of who were non ambulatory, Schindl et al reported significant improvement in functional ambulation of all 10 children after 3 months of BWSTT [13]. In 2004, Day et al reported a case study in which a 9 year old child with spastic tetraplegic CP who could not support his own weight and had never experienced walking began to walk short distances with a rolling walker after 44 sessions of locomotor's training that included BWSTT[9].

At the current time very little researches exists on how altering the amount of support used with BWSTT changes the patient gait parameters improvement in the cerebral palsied pediatric population. Despite the lack of articles pertaining to the use of BWSTT in children with CP, the evidence that is there points to positive effects from the use of this technique [14].

Aim of the work:

The purpose of this study was to assess quantitatively the effect of treadmill training on gait parameters in hemiplegics cerebral palsied children.

Subjects, materials and methods

Subjects:

The present study included twenty six hemiplegics cerebral palsied children, ranging in age between eight and twelve years. They were twelve boys and eight girls (eleven of them were right- while nine were left-side hemiplegia). Age of patients ranged from 9 to 15 years of age, These patients were selected from the out patient clinics, hospitals and schools in Shoubra, Cairo area. Date of onset for all patients was in the first two years of life. All patients have never received treadmill gait training using neuromuscular electrical stimulation at any time before the study. The patients were randomly divided into two equal groups, study and control, each comprised ten patients.

The patients selected met the following basic criteria:

All children with cerebral palsy had a physician's diagnosis of spastic Hemiplegia..

1. Able to walk independently with or without assistive device(crutches, walkers or braces)
2. Mild spasticity, which has been confirmed clinically, according to Ashworth's Scale (***Bohannon and Smith 1987)***[15]***.***
3. None of them has demonstrated any contracture of the affected lower limb, that may interfere with the ability for full weight bearing.
4. No significant endurance impairments due cardiovascular limitation based on patient's health history.
5. No musculoskeletal or neuromuscular surgical procedure within the last Year.
6. Sufficient cognition should be demonstrated to understand the requirements of The study.

Materials:

***1) For treatment*:**

a) Treadmill
b) Biodex unweighing system with hydraulic lift.
c) A Harness.
d) A Built in scale that measure the subject's body weight.
e) Tefal electronic device (weight scale).

***2) For evaluation*:**

a) Walking sheet: 10 meters long, divided at 1-cm intervals.
b) Recording and displaying system:
   1. Video set camera and tapes.
   2. Color TV.
   3. Stop watch.
c) Tape measure.
d) The Bruininks-Oseretsky Test of Motor Proficiency Subset 2 for Balance (**Form 1**)

Form (1): The Bruininks-Oseretsky Test of Motor Proficiency Subset 2 for balance.

Action	Duration	Point Score		Total Score
		Trial 1	Trial 2	
Standing on preferred leg on floor	10 seconds maximum per trial	( ) seconds 0 1 2 3 4	( ) seconds 0 1 2 3 4	
Standing on preferred leg on balance beam	10 seconds maximum per trial	( ) seconds 0 1 2 3 4 5 6	( ) seconds 0 1 2 3 4 5 6	
Standing on preferred leg on balance beam-eyes closed	10 seconds maximum per trial	( ) seconds 0 1 2 3 4 5 6 7	( ) seconds 0 1 2 3 4 5 6 7	
Walking forward on walking line	6 seconds maximum per trial	( ) steps 0 1 2 3	( ) steps 0123	
Walking forward on balance beam.	6 seconds maximum per trial	( ) steps 01 2 3 4	( ) steps 0123	
Walking forward heel-to-toe on walking line	6 seconds maximum per trial	( ) steps 0123	( ) steps 0123	
Walking forward heel-to-toe on balance beam.	6 seconds maximum per trial	( ) steps 0 1 2 3 4	( ) steps 0123 4	
Stepping over response speed Stick on balance beam	10 seconds maximum per trial	( ) steps 0123	( ) steps 01	

Adopted from Bruininks **(1987)** [16]

Methods:

1) For evaluation:

a) Age, Sex were recorded. Weight, height and body mass index (BMI) were done according to standardized methods.

b) Gait evaluation:

The walking sheet was positioned on the floor of the gait evaluation area and fastened on both sides. The subjects were instructed to walk as normally as they used to, from the start to the end of the walkway. This was repeated three successive times. Then, the subjects were videotaped along the ten-meter long of the sheet. The videotape was then played back on the TV for the measurement of the temporal and distance gait -parameters, as follows:

Stride length: The distance between two successive placement of the same foot.

Cadence: The number of steps taken per minute.

Velocity: The distance covered in a minute.

(Smidt G, 1990)[17]

c) Balance evaluation:

Balance was examined, using the Bruininks-oseretsky Test of Motor Proficiency Subset 2 for balance. Each test was repeated for two times, after which the final score was calculated.

All evaluation procedures were conducted by the same investigator for each patient before and after the suggested period of treatment.

2) For treatment:

a) Patients belonging to the control group were subjected to a traditional physical therapy program, comprising passive stretching, weight-shifting exercises and gait training activities.

b) In addition to the previously mentioned traditional physical therapy program, patients involved in the study group performed treadmill gait training, three times a week, 20 minutes each session. All patients used the Partial body weight support (PBWS) based on the child's needs of his/her weight relief.

The following steps were taken:

- Upon arriving to the treatment area the subjects of the study group were given an overview of the treatment procedure.
- They were also instructed on how to safely step onto and of the treadmill.
- The subjects were fitted with the harness with support across the buttocks and around the thighs, as well as around the rib cage, while allowing free movements of the arms, the harness suspended from an overhead support and the support allowed free movement of the lower extremities, then the subjects were weighted on the previously calibrated Tefal Electronic Device (weight scale), this weight was used to calculate the support needed for each subject.
- The height of the treadmill system can be adjusted so the child puts very little weight on his/her feet while walking, reducing the amount of effort needed to "walk."
- The subjects then walked on the treadmill to become familiar with treadmill and determine their self-selected walking speed (Their preferred speed), then the treadmill was stopped, and appropriate amount of unweighting of each subject was adjusted.

    - The investigator was positioned next to the treadmill to guard the subjects from falling.
    - The subjects were instructed to continue walking for10 minuets and progressed to 20 minutes by the end of the third week.

Treatment for both groups continued for twelve successive weeks, three sessions per week. Each session lasted about 20 minutes.

Results

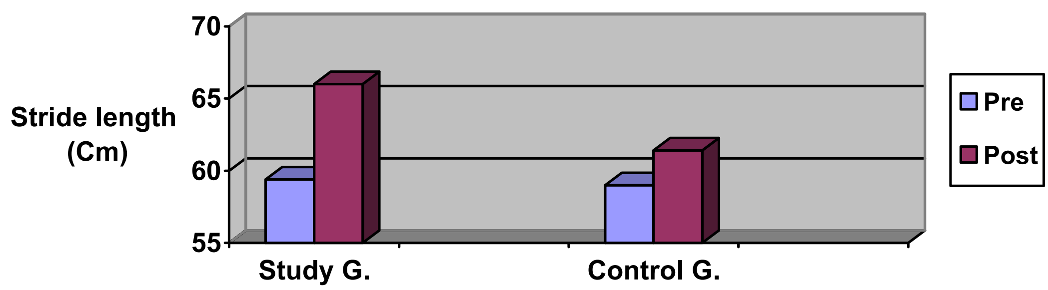
Statistical comparison between values obtained before and after training were done using T tests. Results are presented as means ± standard deviation (SD). Differences were considered significant at 5% ($p<0.05$). Comparison between mean values of all variables in both study and control groups before application of treatment revealed significant differences ($p > 0.05$).

As shown in table (1), the mean value of the stride length in study group before treatment was 59.4Cm, which increased after the suggested period of treatment to 66.0 Cm. The percent of improvement was 11 %,which revealed a highly significant difference ($t = 7.92$, $p < 0.001$) and the mean value of the stride length in control group before treatment was 59.0 Cm , which increased after the suggested period of treatment to 61.4 Cm. The percent of improvement was 4 %, which revealed a significant difference ($t = 2.714$, $p < 0.025$)

Table (1): Shows mean values of stride length (in cm) in both control and Study group after treatment

Comparison	Study		Control	
	Pre	After	Pre	After
Mean	59.4	66.0	59.0	61.4
SD	5.92	5.436	6.342	7.662
MD	6.6		2.4	
t	7.92		2.714	
p	< 0.001		.025	

Fig(1): Shows mean values of stride length (in cm) in both study and control groups

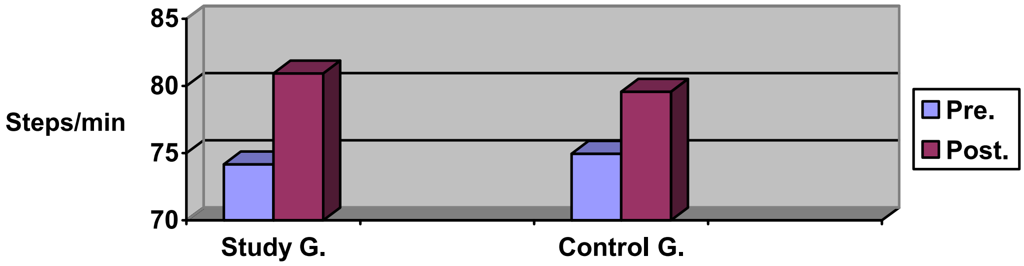


As shown from table (2) and fig. (2), the mean values of cadence in the study group before and after the suggested period of treatment were 74.16 ± .7.386 and 80.92 ± 6.369(in steps/min), respectively. The mean difference was 6.76, which was statistically highly significant ($p < 0.001$). The mean value of cadence **in** the control group increased from 74.96 ± 7.295(in steps/min) before treatment to be 79.57 ± 8.135 (in steps/min) after treatment, which indicated a significant improvement ($p < 0.05$).

Table (2): **Shows mean values of cadence (in steps/min) in both Study and control groups before and after treatment.**

Control		Study		Comparison
Post	**Pre**	**Post**	**Pre**	
79.57	74.96	80.92	74.16	**Mean**
8.135	7.295	6.369	7.386	**SD**
.39		6.76		**MD**
.241		6.002		**t**
< .815		< .001		***p***

Fig(2): Shows mean values of cadence (in steps/m) in both study and control groups

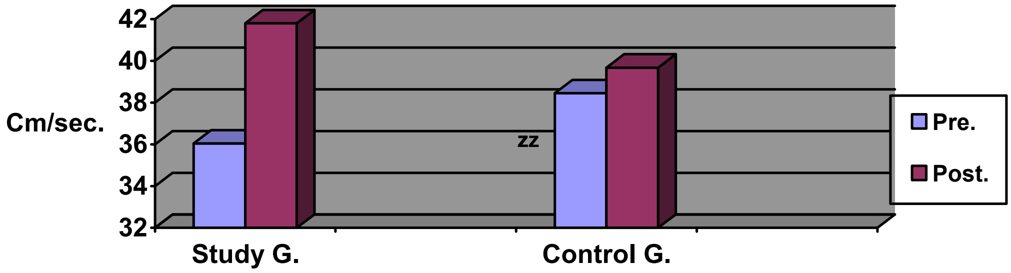


As shown from table (3) and fig. (3), the mean value of velocity in the study group before treatment was 36.03 ± 4.495 Cm/sec, which increased to 41.8 ± 3.705 cm, after 12 weeks of treatment. The mean difference was 5.75, which represented a highly significant difference ($p < 0.001$). In the control group, the mean value of velocity underwent an increase from 38.45 ± 4.272 Cm before treatment to be 39.67 ± 3.637 Cm after application of the traditional physical therapy program, with a mean difference of 1.22, which was also statistically significant ($p<0.032$).

Table (3): **Shows mean values of velocity of walking (in cm/sec) in both Study and control groups before and after treatment.**

Control		Study		Comparison
Post	**Pre**	**Post**	**Pre**	
39.67	38.45	41.8	36.O5	**Mean**
3.637	4.272	3.705	4.495	**SD**
1.22		5.75		**MD**
2.542		8.4		**t**
< .032		< 0.001		***p***

Fig(3): Shows mean values of velocity (in cm/sec) in both study and control groups

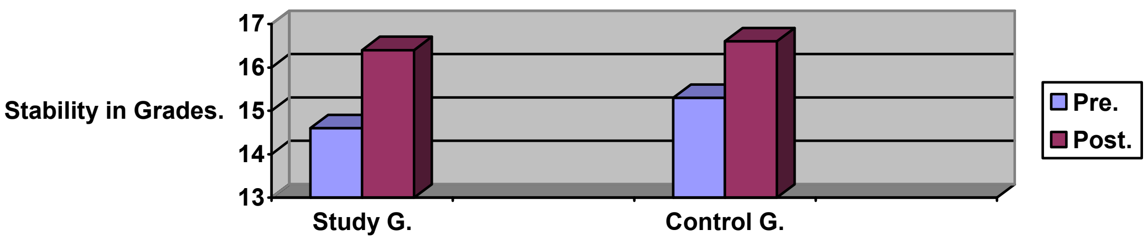


From table (4) and fig. (4), it can be shown that in the study group, the mean values of the grades of stability before and after treatment was 14.6 ± 0.966 and 16.4 ± 2.75 (grades), respectively. The mean difference was.1.8 grades, which was statistically highly significant (p< 0.001). Meanwhile, the mean values of these grades in the control group before and after treatment were 15.3 ± 1.494 and 16.6 ± 1.577(grades), respectively, showing a mean difference of 1.3 (grades) which was also statistically significant (p < 0.05).

Table (4): **Shows mean values of Stability (in grades) in both studies and control groups before and after treatment.**

Control Group		Study		comparison
Post	Pre	Post	Pre	
16.6	15.3	16.4	14.6	Mean
1.577	1.494	2.75	.966	SD
1.3		1.8		MD
3.545		1.765		t
< 0.006		< 0.001		*p*

Fig(4): shows mean values of stability (in grades in both study and control groups



Discussion

CP may lead to profound muscle weakness in the affected extremities. Stackhouse et al demonstrated that children with CP have large deficits in voluntary muscle activation as compared to a group of age-matched unaffected children6. This inability to produce sufficient force using voluntary contractions may not induce muscle growth during training exercises prescribed for CP children. **(Russell DJ et al 2000)[2], (Stackhouse SK et al 2007) [18].**

Dr. Bonato previously stated, there is growing evidence that the human central nervous system is capable of significant recovery after insult or injury when prescribed an effective treatment modality at the proper dose. **(Foss ML, Keteylan SJ. (1998)[8] (Stackhouse SK et al 2007) [19].**

In this study we examined the changes in gait parameters associated with body weight supported tread mill training. We Utilizing gait evaluation parameters, including step length (st/cm.), stride length (str/cm.), cadence (Cs/min.), Velocity (Vcm/sec.) and the Bruininks-Oseretsky Test Motor Proficiency Subtest 2 for balance. The results at the end of the treatment period indicated significant improvement in stride length, cadence, gait velocity and balance. Furthermore, highly significant differences were also noted, at the end of the treatment period, between the mean values of the measured parameters, in the favor of the study group. Such significant differences reflect the great influence of the treadmill body weight support training in treatment of hemiplegics cerebral palsied children.

The finding of the present study indicated considerable difference in measuring mean values of stride length in groups, the control group and the study group, as compared with pre treatment values. A significant difference was also recorded between the mean values of cadence and velocity of walking in both control and study group, but they were highly significance in favor for the study group.

Results of the present study demonstrated that the children of the study group were able to perform alternating stepping pattern when supported on a motorized treadmill. The results also show highly significant improvement of distance and temporal parameters of gait in the favor of the study group, including stride length, affected limb step length, cadence, and velocity. This improvement was attributed to its effect on proper alignment and muscle activation with every step and a greater effect on neural connection in spinal cord.

The present results came in agreement with those of **Dodd KJ and Foley (2007)[20]** who have shown pattern of walking seen in children with CP is very similar to the leg muscle activity described in stepping newborns. They assumed that in children with cerebral palsy, the locomotors pattern cannot mature because of impaired supraspinal influence, and the impact of BWSTT is shown to have a greater affect on neuronal connections in spinal cord.

The results provide additional support for **Schidle et al,(2000)**[13], who reported that stretching the hip flexors in terminal stance stimulates the primary nerve ending of the muscle spindles, thereby activating the muscles and initiating the leg to come forward. In addition, the increased tension placed on the Triceps Surae by loading the limb in mid-stance during BWSTT, has also found to facilitate muscle activation.

The results of this piece of work were also coincident with those of **Hesse et al. (1999)** [21], who stated that BWSTT is beneficial as a treatment method because the movement of the lower extremities into extension afforded by the treadmill assists in stimulating a stepping response not otherwise able to be elicited. While upright and safe position of the patient not only functional for the patient, but it also allows the therapist to be more effective.

The result of the present study also came in agreement with those stated by **Mc Nevin et al, (2000)**[22, who stated that BWSTT, is reported to help Adolescent Cerebral Palsy: improve balance, increase stride length, decrease fear, increase cadence and increase endurance. This study demonstrated that body supported treadmill training is an effective measures in improving gait parameters of spastic hemiplegics children.

However, while therapists are using BWSTT because of its clinical effectiveness, evidence supporting the clinical significant of the treatment method still rather limited.

The findings of the present study are consistent with **Provost et al,** reported improvement in four out of six ambulatory children with CP after only 2 weeks of BWSTT in twice daily therapy sessions lasting 30 minutes each [23]. Four of these children showed improvement in endurance and a functional gait measure. The results of this study at the end of the treatment period confirmed also the findings of **Begnoche et al,** who combined intensive physical therapy with BWSTT in a study of 5 children with spastic CP. The training sessions consisted of 4 weeks of training, three to four sessions per week for 2 hours each. All five children showed significant improvements in motor and ambulatory skills [14]. Finally, the findings of the present study are consistent with **Dodd and Foley 2007**,who conducted a small, controlled clinical trial of 14 children who were matched according to type of CP (spastic, athetoid), age, sex and gross motor functional classification system level. The experimental group underwent BWSTT twice a week for 6 weeks in a school-based program. The experimental group showed significant improvements over the control group in walking speed and a trend towards increased endurance over the range of moderate to severe disability [20].

Conclusion

According to these results, it can be concluded that Treadmill training in addition to traditional physical therapy may be considered as an effective physical therapy modality in improving ambulation and gait parameters in hemiplegics cerebral palsied children. I re-emphasize that there is the great need for more rigorous, well-controlled clinical trials to provide definitive scientific evidence for the widespread use of this promising intervention for the improvement of gait and ambulatory skills in children with CP.I urge investigators interested in the neurorehabilitation of CP to begin to collaborate on issues of dose, frequency of therapy and different combinations of treatment modalities so that the much needed large clinical trials can begin to take place. Without these studies, treatment advances that are taking place in the treatment of stroke, spinal cord injury and other nervous system disorders will not be realized in the treatment of CP.

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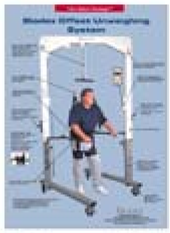
تأثيرالتدريب بإستخدام جهاز المشى الكهربائى على المشى للاطفال المصابين بالشلل المخي التصلبي

د/ رضا سيد محمد سرحان
قسم العلاج الطبيعى - كلية العلوم الطبية التطبيقية - جامعة الملك عبد العزيز.

ملخص البحث:

الهدف من الدراسة هو تقييم تأثيرالتدريب بإستخدام جهاز المشى الكهربائى على لدي الأطفال المصابين بالشلل النصفي التصلبي.

اشتمل البحث على عشرون طفلا من المصابين بالشلل النصفي التصلبي من الجنسين ممن تراوحت أعمارهم بين ٩ و ١٥ عاما، وقد تم اختيارهم طبقا لبعض المعايير الأساسية، تم تقسيم المرضى عشوائيا إلى مجموعتين (المجموعة محل البحث والمجموعة الضابطة)، عولجت المجموعة الضابطة بواسطة العلاج التقليدي بينما عولجت المجموعة محل البحث باستخدام جهاز المشى الكهربائى بالإضافة إلى العلاج التقليدي، استمر علاج المجموعتين لمدة إثنى عشرأسبوعا بواقع ثلاثة جلسات أسبوعيا، وقد تم قياس عناصر المشي التي اشتملت على متوسط طول الخطوتين المتتاليتين، النسبة بين طول الخطوة للساق المصابة إلى طول الخطوتين المتتاليتين، معدل عدد الخطوات، بالإضافة إلى سرعة المشي لجميع المرضى في كلتا المجموعتين قبل وبعد فترة العلاج.أظهرت نتائج البحث وجود فروق ذات دلالة إحصائية بين القياس قبل وبعد العلاج في المجموعتين، بالإضافة إلى وجود فروق ذات دلالة إحصائية بين نتائج المجموعتين بعد انتهاء فترة العلاج لصالح المجموعة محل البحث، وطبقا لهذه النتائج فانه يوصى باستخدام التدريب بإستخدام جهاز المشى الكهربائى في علاج مرض الشلل النصفي التصلبي إلى جانب وسائل العلاج التقليدية.



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