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Efficacy of Unweighing System During Over Ground Walking Versus Treadmill Training on Walking Speed in Spastic Diplegic Children

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ABSTRACT

Background: *The ability to walk is a major concern of the parents of children with CP, the main problem in spastic diplegia is walking difficulty. Balance disturbance, muscle weakness, spasticity and deformities result in abnormal gait patterns typical for diplegic children.*

Objective: *The purpose of this study was to compare the effect of unweighing system during over ground walking versus treadmill training on walking speed in children with spastic diplegic cerebral palsy.*

Methods: *Twenty children with spastic diplegic C.P from both sexes, with Gross Motor Function Classification System levels (II & III) and mean age 7.4 years, participated in this study. They were classified into two groups, group (A) who received partial body weight support (30% weight release) with over ground walking and selected physical therapy program, and group (B), who received partial body weight support with treadmill training and selected physical therapy program. Walking speed was measured before and two months after treatment program through using Biodex Gait Trainer II.*

Results: *The results revealed statistically significant improvement (P<0.05) in walking speed for both groups with insignificant difference between both groups.*

Conclusion: *These findings suggested that unweighing system can be used during treadmill training or over ground walking to improve walking speed in spastic diplegic children while it is better to be used with over ground gait training.*

Key Words: *Cerebral palsy, Diplegic, Unweighing system, Gait training.*

INTRODUCTION

Cerebral palsy (CP) is a non-progressive disorder, meaning the brain damage does not worsen, but secondary orthopedic difficulties are common. There is no known cure for CP. Medical intervention is limited to the treatment and prevention of complications possible from CP's consequences.[1]

Spastic diplegia is the common term applied to variation of spastic quadriparesis in which the lower limbs are more affected than upper limbs. It account for approximately 50% of total CP population.[2]

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 cerebral palsy may require a walker or leg braces. Intelligence and language skills are usually normal.[3]

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.[4]

Among the different percentages of BWS that can be used, the majority of studies evaluating treadmill walking adopted a 30% BWS due to its effectiveness in improving walking performance. The differences between over ground and treadmill walking without BWS have been investigated in healthy individuals 8-11 and in hemiparetic stroke patients. The characteristics of locomotion, such as joint angles or spatial-temporal parameters and functional walking are influenced by the type of walking surface. Thus, it may be that walking training on a treadmill may interfere with the proper transfer of skills to over ground walking which is the walking surface used by individuals on a daily basis.[5]

Among those individuals with locomotor impairment, one group that can benefit from walking training with BWS is children with cerebral palsy, since the development of an independent and efficient walking is one of the major targets for this group.[6]

Ambulation with or without assistance in children with CP is important for participation in activities of daily living 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 benefits gained from ambulation are increased cardiopulmonary endurance and obesity prevention.[7]

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.[8]

MATERIAL AND METHODS

In this study; twenty children with spastic diplegic cerebral palsy of both sexes were selected from the outpatient clinic, Faculty of Physical Therapy, Cairo University were divided in 2 groups, group A (had selected physical therapy program and unweighing system with over ground gait training) and group B (had selected physical therapy program and unweighing system with treadmill training) of the following inclusive criteria; Their ages ranged from six to eleven years, were able to ambulate, they had gait problems (Level II or III According to Gross Motor Function Measure (GMFM)), they should have normal visual and auditory functions, they should be able to follow the instructions, had no convulsions, had no history of surgical interference, their heights were 1 meter and more to be able to see the screen of Biodex Gait Trainer II TM 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.

To assess walking speed 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. (Biodex Medical INC., Shirley, New York, USA).

Gross Motor Functional Classification Scale (GMFCS) was used to assess level of the children performance and independence to be included in this study, the 88 items of the GMFM are measured by observation of the child and scored on a 4-point ordinal scale (05does not initiate, 15 initiates, 10% of activity, 25partially completes 10% to, 100% of activity, 35completes activity). The items are weighted equally and grouped into 5 dimensions: (1) lying and rolling (17 items), (2) sitting (20 items), (3) crawling and kneeling (14 items), (4) standing (13 items), and (5) walking, running, jumping (24 items). By the age of 5 years, children without motor delays can generally accomplish all of the items of the GMFM. Scores for each dimension is expressed as a percentage of the maximum score for that dimension. The total score is obtained by averaging the percentage scores across the 5 dimensions. The original intent of the GMFM developers was to have one measure that could be used for children across a spectrum of ability levels in order to make it possible for children with different gross motor abilities to enter clinical trials and be assessed with the same measurement tool. In addition, the measure needed to be useful for tracking individual children over time. Although items tend to increase in difficulty within a dimension, their ordering was based on clinical judgment and the literature, and the order had not been substantiated with data-based evidence. Items were grouped into dimensions primarily for ease of administration.(9)

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 treadmill training and over ground walking.

Selected physical therapy program for the children enrolled in both groups consisted of the following; Activities designed to practice bending over from a standing position, actively stretching both the hamstrings and gastrocnemius muscles, walking unassisted between parallel bar, walking from therapist to parent with assistance, climbing stairs both ascending and descending. Colored stars were placed on the left and right side of these stairs, and the child climbed them according to the color as directed by the physical therapist. This took place at the beginning and end of each session, gait training using stepper with Colored stars were placed on the left and right side of these stepper, and the child walk according to the color as directed by the physical therapist, walking with the toes pointed up using wedges, and also passive stretching of the gastrocnemius and hamstrings.

The protocol of this study was approved by the ethical committees of the faculty of physical therapy (Cairo University. Egypt). Following an explanation of the experimental protocols, written informed consent was 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). 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

Twenty male and female children participated in the study. They were divided into two groups (group A and B). Group (A) consisted of 10 participants (8 male and 2 female) with mean ± SD age, weight and height of 7.42 ± 0.75 years, 21.83 ± 2.48kg, and 116.66 ± 12.11 cm respectively. Group (B) consisted of 10 participants (7 male and 3 female) with mean ± SD age, weight, and height of 7.46 ± 0.97 years, 20.66 ± 2.65 kg, and 117.79 ±13.66 cm respectively. Two independent t-tests were conducted to compare between both groups for the demographic data (weight and height). The independent t-tests revealed that there were no significant differences between both groups for weight ($t = -0.56$, $p = 0.58$) and height ($t = -2.012$, $p = 0.07$). Data were obtained from both groups (group A and group B), statistically analyzed and compared with measurable variable [walking speed] using paired and unpaired T-test to detect level of significance.

Data presented in table (1) and illustrated in figure (1) showed that, in group A, the pre and post treatment mean values ± SD of walking speed were 0.32± 0.158 and 0.5967± 0.124 (M/Sec) respectively. The difference between the pre and post treatment mean values ± SD of walking speed was extremely significant ($P<0.05$). The percentage of change was 86.26% which indicated post treatment improvement. While in group B, the pre and post treatment mean values ± SD of walking speed were 0.335± 0.16 and 0.5167± 0.156 (M/Sec) respectively. The difference between the pre and post treatment mean values ± SD of walking speed was highly significant ($P<0.05$). The percentage of change was 54.33% which indicated post treatment improvement.

Item	Walking Speed (M/Sec) _Pre X+SD	Walking Speed (M/Sec) _Post X+SD	Mean Difference	% of Change	T value	P Value	Significance
Group A	0.32+ 0.16	0.5967+ 0.12	0.276	86.26	5.53	0.0003	Extremely S
Group B	0.34+ 0.16	0.5167+ 0.16	0.182	54.33	2.762	0.013	Highly S

Table (1) shows pre and post mean values of walking speed (M/Sec) in both groups A and B which indicated that there was an extremely significant difference between pre and post treatment mean values in groups A, while there was a highly significant difference between pre and post treatment mean values in group B.

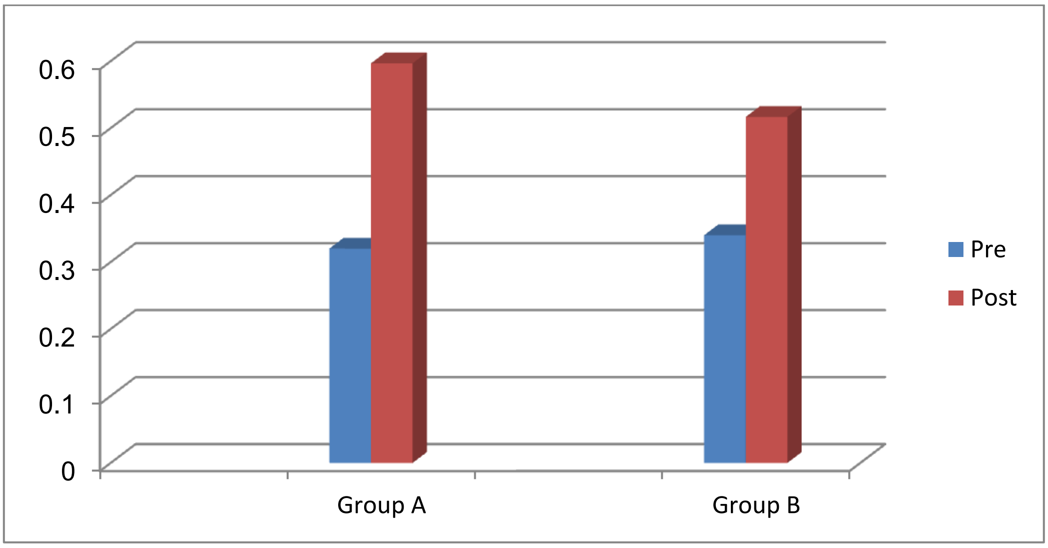

Figure (1): Pre and post mean values of walking speed (M/Sec) in both groups A and B.

When comparing pre and post treatment mean values of walking speed in both groups (A and B); It's evident from table (2) and demonstrated in figure (2) that, the pre treatment mean values +SD of walking speed for both groups (A and B) were 0.32+0.158 and 0.335+0.16 (M/Sec) respectively, which indicated no significant difference (P>0.05). While post treatment mean values +SD of walking speed for both groups (A and B) were 0.5967+0.12 and 0.5167+0.16 respectively which also indicated no significant difference between both groups (P>0.05).

Item		Group A	Group B	Mean Difference	T Value	P Value	Significance
Walking Speed (M/Sec)	**_Pre X+SD**	0.32+0.158	0.335+0.16	0.015	0.163	0.87	NS
	_Post X+SD	0.5967+0.12	0.5167+0.16	0.80	0.984	0.35	NS

Table (2) shows pre and post treatment mean values of walking speed (M/Sec) for both groups (A and B) and revealed that there were no significant differences between pre and post treatment mean values ±SD of walking speed between both groups (A and B).

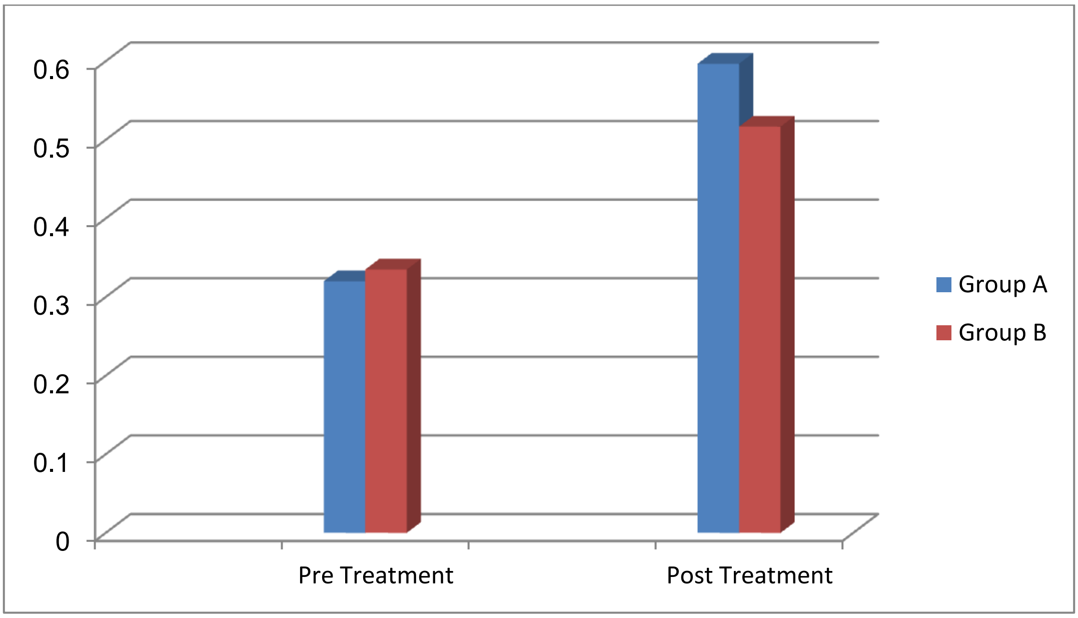

Figure (2): Pre and post treatment mean values of walking speed (M/Sec) for both groups (A and B).

DISCUSSION

Gait limitations in children with CP are common. Reduced walking speed and endurance are two of the main functional problems.6 In addition, gait deviations including, but not limited to, decreased step and stride length, decreased speed, decreased toe clearance, and timing issues affect the ability of a child with CP to ambulate independently and efficaciously in home and community environments.7 Children with CP at Gross Motor Function Classification System (GMFCS) levels III–V have additional limitations and issues with ambulation, secondary to their increased need for assistance and support during ambulation. [10]

Clinical presentations and preliminary reports about partial body-weight support training during treadmill or over ground walking have physical encouraged physical therapists to explore this intervention to address gait limitations in children with CP. Unweighing system either during treadmill or over ground walking as an intervention is also potentially attractive as it may address gait limitations more effectively, because it allows one to address gait to be addressed at multiple levels of the International Classification of Functioning, Disability and Health (ICF). Interest in unweighing system for children with CP is rapidly increasing.[11]

Over the past 10 years, an increased effort has been made in pediatric rehabilitation to provide children with CP at all GMFCS levels with opportunities to walk in an upright position. This effort has emphasized the use of locomotor system with various degrees of partial weight support. The locomotor system consists of a harness suspension system in which the child is suspended over the treadmill or over ground to facilitate the standing position. Harnesses are available in pediatric and adult sizes, and the suspension systems can be outfitted with electronic lifting mechanisms for heavier children. Scales are available to measure the amount of weight support given to the child on both sides or on one side of the body. If a child is unable to perform the necessary stepping motion independently, a physical therapist provides assistance with stepping as needed.(12)

Ambulation is a challenging task for children with CP and its achievement is an important therapeutic goal. Locomotor training can be used to provide task-specific training and multiple repetitions of the walking task in a safe and supportive environment for children of various ages and with different severities and types of CP. Although improved walking speed, endurance, and gross motor skills related to ambulation were observed following locomotor training in children with CP younger than 4 years, the evidence is considered preliminary. Stronger evidence exists for the positive effects of locomotor training on these ambulatory parameters in school-aged children. In these studies, longer duration and higher intensity locomotor training protocols showed greater improvements in walking attainment, walking speed, and endurance than shorter, less intensive programs. Furthermore, children with mild motor impairment made relatively more progress when provided with locomotor training than children exhibiting more severe impairment. Finally, no adverse reactions have been reported as a result of locomotor training either during treadmill or over ground walking.(13)

Partial body weight support (BWS) during treadmill or over ground walking 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.(14)

The use of partial weight support during gait training may be of benefit to patients with cerebral palsy (CP) because the reduction in load places fewer demands on muscles involved in both propulsion and balance.(15)

The unweighing (partial body support with parachute Harness) activates the gait stepping generators, leads to a more regular gait pattern, reduces spasticity of the plantar flexors, and improves gait symmetry in diplegic subjects. External assistance of the gait cycle is usually required during the transition from stance to swing. Knee and hip joints should be fully extended during the stance phase to optimally support body weight. Hyperextension of the knee joint should be avoided. The pelvis should be kept fixed, so that loading of the knee and ankle occurs in a physiological manner. Optimal velocity and rhythmicity must be grasped and tuned. Increase in the velocity of the spastic gait should be achieved by reducing the duration of the stance phase rather than the swing phase.(16)

Regarding the type of walking surface, most of the differences found in spatial-temporal variables may have been due to the characteristics of the treadmill and the speed at which children walked. For example, the length of the treadmill may interfere with the length of the stride. Additionally, due to the fact that the treadmill is a moving surface, walking on that surface is more unstable than walking over ground and this may also decrease the length and speed of the stride. Because the mean walking speed interferes with spatial-temporal characteristics of walking, the stride length and speed could have been similar between the two types of surfaces if the treadmill speed had been set closely to the speed at which children walked over ground. However, because children with CP are not used to walk on the treadmill, this may have prevented them to feel comfortable walking at a faster speed which is commonly felt during over ground walking.[16]

In terms of the disadvantages, treadmill walking requires a higher control of propulsion and balance compared to over ground walking [17]. In terms of propulsion, while walking over ground requires the application of enough force to alternately move the right and left limbs forward, walking on a treadmill using some type of external support (e.g. BWS, side bars) generates a force that is not necessarily proportional to the speed.[16] It is also possible that in this situation the limbs might be passively moved by the treadmill without any change in muscular activation[6], with the child simply raising and lowering the limbs while the treadmill belt is moving. In terms of balance control, because the treadmill is a moving surface, the walking strategy to keep stability can be different from that used for over ground walking. This aspect was observed in this study through the variables duration of single-stance and double-stance periods, which were previously discussed. The disadvantages of using a treadmill may limit the transfer of skills to over ground walking [17], since the strategies required for treadmill walking are not necessarily the same for over ground walking, which is the type of surface that we normally walk.

Finally, it's worthy to be mentioned that there were a significant improvement in walking speed in both groups (A and B) participated in this study. Although there was no significant difference between groups, the level of improvement was much higher in group A (unweighing system with over ground gait training) than group B (unweighing system with treadmill gait training).

This study had some limitations that need to be acknowledged, such as the differences between the speed of treadmill and over ground walking, and the small sample size.

CONCLUSION

The results of this study indicate that Biodex unweighing system can be used during over ground gait training or treadmill training to improve walking speed in children with spastic diplegia while it's more effective when used with over ground gait training.

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