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Original Research Article

# UNDERWATER EXERCISES VERSUS TREADMILL TRAINING ON GAIT IN CHILDREN WITH SPASTIC HEMIPARETIC CEREBRAL PALSY

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## ABSTRACT

**Purpose:** The aim of the study was designed to compare the effect of underwater exercise and treadmill training on gait parameters in hemiparetic cerebral palsied children.

**Subjects and methods**: thirty hemiparetic CP children from both sexes (16 boys and 14 girls), their age ranged from seven to nine years old, were recruited from the out patient's clinic of Faculty of Physical Therapy , Cairo University and from National Institute of Neuromotor System. They were randomly assigned into two equal groups; underwater intervention group and treadmill training group.

**Procedures:** parameters (average walking speed, step length, and time on each foot distribution) are assessed by using the Biodex gait trainer 2 pre and post three months of the treatment. Children in study group 1 received underwater exercise program while children in group 2 received treadmill training ,three times per week for three months.

**Results:** There was a statistically significant improvement in the measured parameters in both groups when comparing their pre and post treatment mean values. However , nonsignificant difference was recorded between post treatment mean values of the two groups.

**Conclusion:** It could be concluded that both programs may be used in addition to selected physical therapy programs to improve gait in hemiparatic cerebral palsy children.

**KEY WORDS:** Hemiparetic cerebral palsy-Underwater exercises- Treadmill-children.

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## INTRODUCTION

Cerebral palsy (CP) is the most common motor disability in childhood [1]. CP is a heterogeneous group of clinical syndromes that describe permanent disorders of movement and posture. It is characterized by abnormal muscle tone, posture, and movement, thereby limiting the activity of the affected person. The motor disorders of CP are often associated with disturbances of sensation, perception, cognition, communication and behavior, epilepsy, and secondary musculoskeletal problems [2].

Population-based studies from around the world revealed that the prevalence measures of CP had ranged from 1.5 to more than 4 per 1,000 live births or children of a defined age range .The overall birth prevalence of CP is approximately 2 per 1,000 live births [3,4].

Cerebral palsied children impairments may result in activity limitations that require rehabilitation throughout life.29% of children with cerebral palsy have hemiplegia, that is, one side of the body is affected much more than the other, and the upper limb is typically more involved than the lower limb [5].

Rehabilitation of cerebral palsy is challenging for health professionals. Different therapies are included in literature which follows multiple theoretical framework. Management strategies are basically designed to improve quality of life, reduce and prevent secondary impairments which limit the movement. Physical therapy plays a central role in managing cerebral palsy; it focuses on function, movement, and optimal use of the child's potential. It uses physical approaches to promote, maintain and restore physical, psychological and social well-being [6-8].

Underwater exercises (aquatic exercise programs ) is a popular treatment with a pain relief effect for many patients with painful neurologic or musculoskeletal conditions [9].It may be a beneficial form of therapy for children and adolescents with cerebral palsy, particularly for those with significant movement limitations where land-based physical activity is difficult. Studies have concluded that performing motor skills in the water can potentially increase confidence and lead to less resistance to difficult tasks compared with land training [10]. Moreover, activities in water can be fun and considered a new experience for children, that result in enhancing motivation and interest[11].

One of the aims of therapeutic interventions in management of cerebral palsied children is to help them achieve maximal independence by improving their functional capacity and mobility [12]. Improving their walking is an essential aim and the use of a treadmill for walking analysis and training may offer several advantages, such as the capability to repeat and train the gait cycle at controlled and fixed walking speeds. Furthermore, it has been suggested that treadmill training is safe, feasible and effective for children and adolescents with CP, especially for those with balance disorders[13].

The gait analysis is an important tool for assessing changes in gait. There are various types of parameters that can be assessed i.e temporal and spatial parameters. The Biodex Gait Trainer 2 is a device used to assess and train walking performance in patients with neurological gait abnormalities. It consists of treadmill with instrumented deck that records kinematic gait parameters including: average walking speed (m/sec) , step length (m) , and time on each foot distribution (% of gait cycle)[14, 15].

**Subjects:** Thirty children with spastic hemiparetic CP from both sexes (16 boys and 14 girls) were recruited from the out patient's clinic of Faculty of Physical Therapy, Cairo University and from National Institute of Neuromotor System.

The study had local research and ethics committee approval and all subjects, parents are given a written consent.

They were randomly assigned into two groups (study I and study II)

**Inclusion and exclusion criteria:** Inclusion criteria to participate in the study for children in both group were: Their ages ranged from seven to nine years. The degree of spasticity ranged from 1 to $1^+$ according to modified Ashworth scale [16]. All participants were able to stand and walk independently with abnormal gait pattern. They can follow instructions.

Children with any musculoskeletal abnormalities, epilepsy , or hearing or visual defects, were excluded.

## INSTRUMENTATION AND PROCEDURES

**Instrumentation:** Biodex gait trainer 2 : It is an effective evaluative and training device for practicing functionally gait pattern. It composed of treadmill with screen that record kinematic gait parameters. Speed and distance of walking can be adapted to the patient requirements.

**Swimming pool, floating device and inflatable toys:** The Swimming pool in the hydrotherapy department of National Institute of Neuromotor system is equipped with bed that can be immersed and controlled in water, pool size was 4.5m× 9.0 m while depth was 1.0m to 1.7m.

**Procedures:**

Step 1) All the children were assessed , and those who fulfilled inclusion criteria were selected for the study. Step 2) All thirty subjects were randomly assigned into two groups, Study group I and study group II Step 3) The procedure was explained to parents of all the children. Step 4) Each child was evaluated before and post the period of training. Children in study group I received a specially designed underwater exercise program, while children in study group II received gait training program using Biodex trainer 2. Both groups were undergone the recommended regular physical therapy program ( strengthening exercises, stretching exercises for the weak and tightened muscles respectively, and facilitation of equilibrium and protective reactions).

**Underwater exercise program:** Water temperature: 32-34ºC is selected according to (Campion, 1997) [17].

Water depth (WD); The water depth was selected to be below level of T11, ( buoyancy dominant) [18].

Session began with warm up exercises which lasted for three to five minutes in the form of slow controlled kicking movements followed by increasing the rhythm of movement. Lower extremity active free and active resisted exercises are performed from supine, semiprone, sitting and standing positions in addition to walking activities in water which were increased gradually and repeated for 20 minutes. The treatment session ended with active or assisted movements activities for cooling down,these activities lasting for three to five minutes. The total treatment session was 30 minutes [19].

**Treadmill exercise program:** Children in study group II received exercise program while assuming standing position, each child was instructed to handle firmly the side bars of the treadmill by both hands, guidance was given to them to look in front and not looking down on their feet while walking. The child was asked to walk steadily on the treadmill for 5 minutes as a warm up. The treadmill was set with zero inclination and 1.5 Kilometer/hour speed. After warm up, the speed was increased gradually to 3 Kilometer/hour with same inclination for 20 minutes , Finally, 5 minutes for cooling down. The total treatment session was 30 min [20].

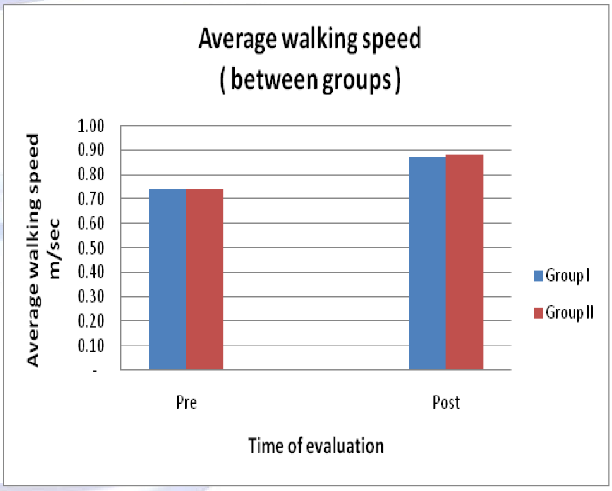
The treatment time was conducted for 3 months for both groups after which all children were assessed by Biodex gait trainer 2.

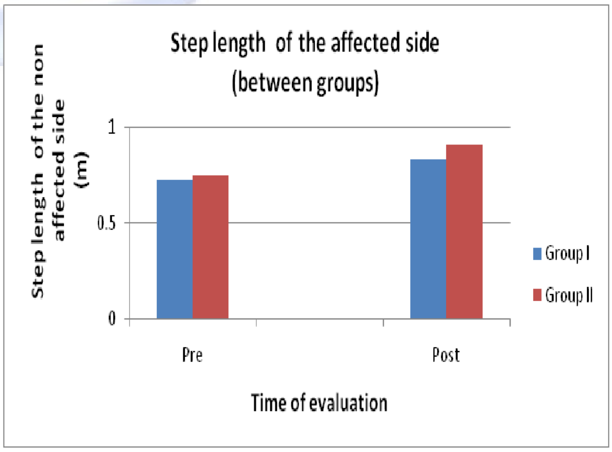
## RESULTS

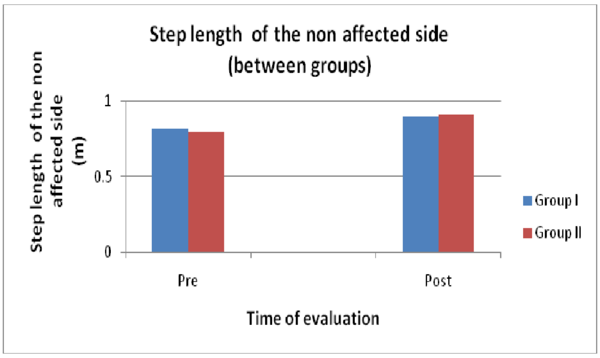
Data management and statistical analysis were performed using statistical package for social science (SPSS) vs.21.

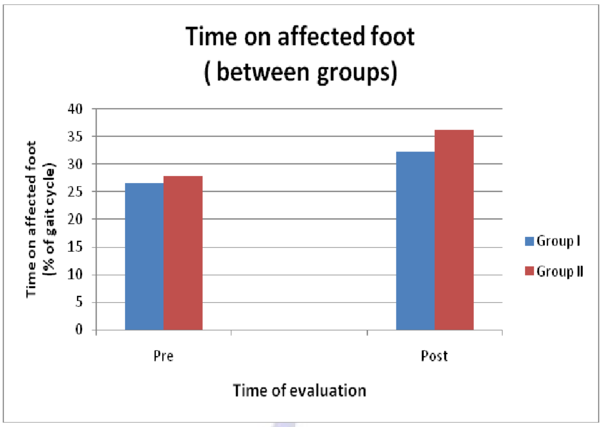
**Demographic and clinical characteristics of children of both groups:** The distribution of boys and girls for group I ( 6 boys and 9 girls) while for group II ( 9 boys and 6 girls ) .Mean ages and standard deviation ( Mean ±SD) of group I and II were (7.07 ± 0.3) and ( 7.0 ± 0.23 ) years respectively. There was no significance difference in all variables between both groups regarding their age.

There were no statistically significant differences in the measured variables regarding to pretreatment values , while two exercise programs resulted in improvement in all tested variables.





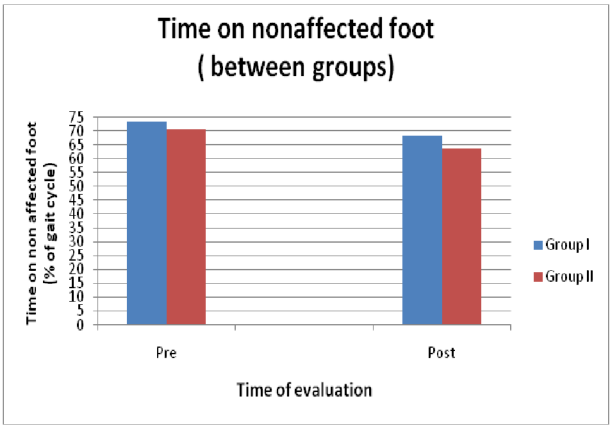




**Table 1:** Comparison between pretreatment mean values of gait parameters for both groups ( I & II ).

| Variables | Group I | | | Group II | | | Comparison | | S |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | ±SD | C.V | Mean | ±SD | C.V | t-value | P-value | |
| Average walking Speed | 0.74 | ±0.09 | 11.6 | 0.74 | ±0.07 | 9.74 | 0.05 | 0.96 | NS |
| Step Length( affected) | 0.73 | ±0.11 | 15.46 | 0.75 | ±0.11 | 14.06 | 0.57 | 0.58 | NS |
| Step Length(non affected) | 0.82 | ±0.11 | 13.85 | 0.8 | ±0.10 | 11.91 | 0.31 | 0.76 | NS |
| Time on affected foot | 26.6 | ±8.19 | 30.8 | 27.87 | ±9.09 | 32.63 | 0.4 | 0.69 | NS |
| Time on non affected foot | 73.4 | ±8.19 | 11.16 | 70.8 | ±7.64 | 10.79 | 0.9 | 0.38 | NS |

*SD: standard deviation, CV: Coefficient of variation, t: unpaired t value, P: probability, S: significance, NS: non-significant.

**Table 2:** Comparison between pre and post treatment mean values of gait parameters for group (I).

| Variable | Pre | | | Post | | | Comparison | | | S |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | ±SD | C.V | Mean | ±SD | C.V | Mean diff. | t-value | P-value | |
| Average walking Speed | 0.74 | ±0.09 | 11.6 | 0.87 | ±0.06 | 7.43 | 0.13 | 8.69 | 0.05 | S |
| Step Length( affected) | 0.73 | ±0.11 | 15.46 | 0.83 | ±0.10 | 12.5 | 0.1 | 7.24 | 0.05 | S |
| Step Length(non affected) | 0.82 | ±0.11 | 13.85 | 0.9 | ±0.09 | 9.86 | 0.09 | 4.11 | 0.05 | S |
| Time on affected foot | 26.6 | ±8.19 | 30.8 | 32.27 | ±8.80 | 27.3 | 5.67 | 15.16 | 0.05 | S |
| Time on non affected foot | 73.4 | ±8.19 | 11.16 | 68.33 | ±8.23 | 12 | 5.07 | 6.27 | 0.05 | S |

*SD: standard deviation, CV: Coefficient of variation, Mean diff: Mean differences, P: probability, S: significance.

**Table 3:** Comparison between pre and post treatment mean values of gait parameters for group(II).

| Variable | Pre | | | Post | | | Comparison | | | S |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | ±SD | C.V | Mean | ±SD | C.V | Mean diff. | t-value | P-value | |
| Average walking Speed | 0.74 | ±0.07 | 9.74 | 0.88 | ±0.07 | 8.26 | 0.14 | 16.21 | 0.05 | S |
| Step Length( affected) | 0.75 | ±0.11 | 14.06 | 0.91 | ±0.10 | 10.6 | 0.16 | 8.93 | 0.05 | S |
| Step Length(non affected) | 0.8 | ±0.10 | 11.91 | 0.91 | ±0.08 | 8.73 | 0.1 | 5.81 | 0.05 | S |
| Time on affected foot | 27.87 | ±9.09 | 32.63 | 36.13 | ±6.51 | 18 | 8.27 | 7.56 | 0.05 | S |
| Time on non affected foot | 70.8 | ±7.64 | 10.79 | 63.87 | ±6.51 | 10.2 | 6.93 | 5.85 | 0.05 | S |

*SD: standard deviation, CV: Coefficient of variation, Mean diff: Mean differences, P: probability, S: significance.

**Table 4:** Comparison between post treatment mean values of gait parameters for both groups (I & II).

| Variables | Group I | | | Group II | | | Comparison | | S |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | ±SD | C.V | Mean | ±SD | C.V | t-value | P-value | |
| Average walking Speed | 0.87 | ±0.06 | 7.43 | 0.88 | ±0.07 | 8.26 | 0.37 | 0.71 | NS |
| Step Length( affected) | 0.83 | ±0.10 | 12.49 | 0.91 | ±0.10 | 10.56 | 2.1 | 0.05 | NS |
| Step Length(non affected) | 0.9 | ±0.09 | 9.86 | 0.91 | ±0.08 | 8.73 | 0.13 | 0.9 | NS |
| Time on affected foot | 32.27 | ±8.80 | 27.26 | 36.13 | ±6.51 | 18.02 | 1.37 | 0.18 | NS |
| Time on non affected foot | 68.33 | ±8.23 | 12.04 | 63.87 | ±6.51 | 10.2 | 1.65 | 0.11 | NS |

* SD: standard deviation, CV: Coefficient of variation, t: unpaired t value, P: probability, S: significance, NS: non-significant.

**Test of relationship between selected variables by using Pearson correlation coefficient:**

There are observed correlations but strong enough to be statistically significant.

**Table 5:** Test of the correlation for selected variables.

| Group | Variables | R | P-Value | Sig. |
|---|---|---|---|---|
| Group I | Average walking Speed and step length of the affected limb( Post - treatment) | 0.04 | 0.89 | NS |
| Group II | Average walking Speed and step length of the affected limb( Post - treatment) | 0.31 | 0.26 | NS |
| Group I | Average walking Speed and time on affected foot ( post-treatment) | 0.15 | 0.6 | NS |
| Group II | Average walking Speed and time on affected foot ( post-treatment) | 0.37 | 0.18 | NS |
| Group I | Step length of the affected limb and time on affected foot ( post-treatment) | 0.09 | 0.75 | NS |
| Group II | Step length of the affected limb and time on affected foot ( post-treatment) | 0.52 | 0.05 | NS |

P: probability, r: Pearson correlation coefficient, NS: non-significant.

## DISCUSSION

The purpose of this study is to compare between underwater exercise program and treadmill training program on selected gait parameters in hemiparetic cerebral palsied children.

Comparison of the pre-treatment results of both study groups with regard to all the measured variables revealed no significant difference (P>0.05), suggesting that both groups were homogenous at the beginning of the study.

Neurological conditions as cerebral palsy have associated impairments that affect motor development and delay postural control , that clearly observed in younger children with CP, which may be attributed to decreased strength , sensory disturbance ,decreased neuromuscular control, impaired equilibrium reactions and coordination of voluntary muscle contraction. Children with hemiparetic cerebral palsy develop abnormal muscle tone and abnormal movement control that may affect their ability to maintain standing and walking balance [2].

The results of the present study after the suggested period of treatment showed significant improvement of all measured variables of gait parameters for both groups when comparing their pre and post treatment mean values which can be explained by the fact that strengthening programs have a positive effect on ambulation, such as increased muscle strength and stride length, plantar-flexor generating power at push off, ability to balance on one leg, negotiating obstacles and climbing stairs that may promote independence in children with CP [21]. The physical therapy exercises focused on facilitation of normal movement patterns for functional activities and directed toward specific functional situations, which exercise programs of the present study is based upon it ,shows that the child should be encouraged to participate in functional and meaningful activities that come in agreement with Wannier et al., (2001) who reported that continuous functional activities [22].

The post treatment improvement in the mean values of gait parameters in group I may be attributed to the increased activity of antigravity muscles , this is supported by the work of Pöyhönen et al., 2001who found that repeated trial exercises become either assisted or resisted by the flowing water as the flowing water creates additional resistance when the moving limb opposes the water flow. Conversely , movement of the body segment accelerates water masses that surround the body parts causing resistance in the beginning of the range of motion. At the end of the range of motion the surrounding fluid continues to flow thus assisting the movement [23].

Aquatic exercises are recommended in rehabilitation of children with neurological disorders especially when exercise under normal conditions of gravity is difficult. Water offers unique medium, in which reduced gravity forces and the application of hydrodynamic principles; bouncy ,and the viscous properties of water act on the exercising body promoting strengthening of weak muscles of extremities[24].

The post-treatment improvements in gait parameters results of group II confirm the findings of Gardner et al., (1998) who stated that the use of treadmill in gait training for hemiplegic persons often focuses on training them to bear weight, shift weight and balance as isolated tasks before these tasks are incorporated into locomotion. Besides, balance improvement allowed these children to increase the time of single limb support, which means increase in hip and knee flexion of the swinged limb and increased time of weight bearing on the beared limb [25]. The results also come in agreement with Laufer et al., ( 2001) 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.and also supported by Smania et al., (2011) who stated that repetitive locomotor training with gait trainer may improve gait velocity, endurance, spatiotemporal, and kinematic gait parameters in patients with cerebral palsy [26,27].

## CONCLUSION

Based on our finding , both underwater exercise program and treadmill exercise training are recommended adjuncts to the physical therapy intervention for children with hemiparesis,

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## Conflicts of interest: **None**

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