Comparing the Effects of Aquatic and Land-Based Exercises on Balance and Walking in Spastic Diplegic Cerebral Palsy Children

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Abstract

Background: Children with spastic diplegic Cerebral Palsy (CP) often show motor impairment due to a number of deficits; including poor muscle control, weakness, spasticity and reduced range of motion in the extremities. All these factors affect the ability of children with CP to maintain balance and walk which are the primary rehabilitation concerns of parents and clinicians.

Aim of the Study: The present study was designed to compare between aquatic and land-based exercises on balance control and gait kinematics in children with spastic diplegia.

Material and Methods: Thirty children with spastic diplegic (CP) of both sexes (19 boys and 11 girls) with gross motor function classification system level (II-III) and age ranged between 6-9 years were included in this study. Children were randomly assigned into two equal groups; Aquatic intervention (AQ) group and land-based exercise (LB) group. Balance parameters (overall, mediolateral and anteroposterior stability indices) were evaluated using biodex balance system™. Also gait kinematics parameters (step length, walking speed and time spent on each foot) were measured using biodex gait trainer II™. Evaluation for each child in both groups was done before and after 12 successive weeks of treatment.

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

Conclusion: The obtained results suggest that the aquatic therapy is beneficial to improve balance control and walking performance in spastic diplegic (CP) children.

Key Words: Cerebral palsy – Aquatic therapy – Land-based exercise – Balance – Gait.

Introduction

CEREBRAL Palsy (CP) is a static, non-progressive disorder that result from brain insult or injury during any of the prenatal, perinatal and postnatal stages. This neurologic disorder leads to lack of motor control and has the potential to disrupt primarily the motor development of the child, affecting the posture and locomotion [1,2].

In spastic diplegic children, abnormal gait patterns can results from disturbance of balance, muscle weakness, spasticity and skeletal deformities [3,4]. These patterns are characterized by lack of mobility in the lumbar spine, pelvis and hip joints and show asymmetric pelvic motion during walking. A lot of the ambulatory children with spastic diplegia were able to attain a walk in the form of a crouch gait with flexed hips, knees and ankles. Crouch gait has been deduced as a result of over activity or shortening of the hamstrings that in turn increases oxygen consumption and cause fatigue [5].

Public exercise and physical fitness programs have been found effective in increasing walking ability of children with CP [6,7]. Specifically, locomotor treadmill training program [8] is along with the most often practiced approaches; can improve CP child gross motor function, speed of walking and endurance [9]. Conversely, despite observed gains in strength, the appropriateness of this training to encourage walking in children with CP has only limited evidence [10,11].

Aquatic (water) exercise is one of the physical therapy approaches used for children with CP. Postural stability can be increased by reducing the effect of the gravitational force by using water; helping the CP child to exercise more effortlessly than on land [12-16]. On this base, children with CP could practice for long duration in aquatic setting, as conditioning extra muscle groups before reaching the sense of fatigue, in contrast to exercising on land. In spite of these benefits, few studies
have examined the effects of aquatic exercise on balance and walking in children with CP. Recent studies in small samples of CP children reported some evidence of aquatic training on improving strength, walking endurance and functional mobility [12,13,15]. However, these studies did not use comparative treatment conditions.

Therefore, the purpose of this study was to compare the outcomes of an Aquatic (AQ) and a Land-Based (LB) training program on balance and gait kinematics in children with CP.

**Patients and Methods**

Thirty CP children aged from six to nine years were enrolled in this study as subjects. Children were selected from the outpatient clinic of the Faculty of Physcial Therapy, Cairo University in the period from July 2014 to February 2015. Participants were randomly assigned to either aquatic or land-based exercise group by opening an opaque envelope prepared by an independent subject with random number generation. Participants were randomly assigned to two equal groups.

Aquatic therapy (AQ) group included 15 children (10 boys and 5 girls) with mean age of 7.8 ± 1.01 years. Land-Based exercise (LB) group included 15 children (9 boys and 6 girls) with mean age of 7.73 ± 1.16 years. Children in both groups participated in the study for 12 weeks, three sessions per week, and each session lasts for one hour. Subjects were diagnosed as having CP with spastic diplegia based on careful clinical assessment by a neuropediatrician and magnetic resonance imaging of the brain. The subjects’ parents signed a written consent forms approved by the Ethics Committee of the Faculty of Physical Therapy, Cairo University, before before the children participated in the study.

**Study design:** This was a randomized controlled trail.

**A- Inclusion criteria:**
- Medical diagnosis of spastic diplegic CP was conducted by pediatricians specialized in pediatric neurology.
- Grade of spasticity ranged from 1 to 1+ according to modified Ashworth scale [16].
- Children were able to walk three minutes at a self paced speed.
- Children had functional performance levels between II-III according to the Gross Motor Function Classification System (GMFCS) [17].
- Children were able to understand and follow verbal commands and instructions included in both test and training procedures.

**B- Exclusion criteria:**
- Children with open wounds and infective skin diseases.
- Children with fever (>38ºC), chest infections or unstable cardiac status.
- Children with urinary and bowel incontinence.
- Children with visual or auditory problems.
- Children with seizures.
- Children had previous history of surgical interference (orthopedic or neurosurgeries).
- Children participated less than 60% of the practice sessions.

**Instrumentation:**

**I- For evaluation:**
All the following measured variables had taken place at the Faculty of Physical Therapy, Cairo University.

- **Modified Ashworth Scale (MAS):** Was used to measure the degree of spasticity by passive movement [15].
- **Weight and height scale:** Reliable weight and height scale was used to measure the weight (kg) and height (cm) of each child. Children were asked to wear light cloths, remove their shoes, stand up straight and look straight ahead for both measurements.
- **Biodex Balance System™:** It is a dynamic postural control assessment and training system (Biodex medical system, Shirley, New York). It consists of a movable balance platform which can be set at variable degrees of instability and safety support rails. This system is interfaced with computer software monitored through the control panel screen [18].
- **Biodex Gait Trainer 2™:** It is a device designed specifically for assessment, rehabilitation and retraining of gait for all patients. It provides both audio and visual feedbacks to facilitate gait training. It is composed of a treadmill with an instrumented deck that monitors and records kinematic gait parameters: Step length (m), walking speed (m/sec) and time on each foot (recorded as a percent of gait cycle). A high resolution color touch screen LCD display is attached to the treadmill to control the device settings [19].
II- For treatment:

- For the aquatic group: A large swimming pool (Hydrotherapy department in the National Institute of Neuromotor System, Giza, Egypt) equipped with suspended chair and plinth, side bars at sides of the pool, balance board and for the child safety each child had his/her own life jacket to assist the child to be supported in the pool.

- For the land-based group: Physical therapy tools of different shapes in the form of: Mats, wedges, rolls, stepper, balance board and medical balls (in the outpatient clinic, Faculty of Physical Therapy, Cairo University).

A- Evaluation session:

I- Dynamic balance testing procedures:

This test was performed to test the child's ability to control the platform's angle of tilt via the Biodex balance system™. All children were given an explanatory session before the evaluation procedures to be aware about the different test steps. Support rails and biofeed back display screen were adjusted for each child to ensure comfort and safety. The display was adjusted so that the child could look straight at it.

The following test parameters were introduced to the device:

- Child's age, weight, and height.
- Platform firmness: All children were tested on stability level (5).
- Test duration: All children were tested for 30 seconds [20].

The outcome measures of dynamic balance testing are:

- Overall stability index: Represents the child's ability to control his balance in all directions.
- Mediolateral stability index: Represents the child's ability to control his balance from side to side.
- Anteroposterior stability index: Represents the child's ability to control his balance in front to back direction.

High values of stability indices represent that child had difficulty in maintaining balance. The previous evaluation procedures of dynamic balance test were carried out for each child individually before, and after three successive months of treatment.

II- For kinematic gait measurements:

The Biodex Gait Trainer 2™ was used to evaluate the gait function of the subjects. The outcome measures were: The Walking Speed (WS) (m/s), Step Length (SL) (cm) and the Stance Time (ST) (%) on each limb. At first, certain parameters were fed to the device. The screen allows entry of child information and parameters used for gait evaluation such as name, age, gender, height and gait evaluation time. To start the evaluation process, the tread belt was ramped up at slow speed of 0.3m/sec with zero degree inclination and gradually increased in 0.2m/sec increments until the maximum speed at which the subject could maintain comfortable walking was reached. Gait evaluation was started once the subjects could maintain a comfortable speed, and the test time was 6 minutes [21].

B- Training session:

For the aquatic group:

Aquatic exercises were done by a qualified physical therapist in water-based exercises. The child wore the life jacket. Before starting the program the following factors were settled: Water temperature (32º-34ºC), room temperature (20º-22ºC), air temperature of pool area 25ºC. Throughout the sessions the children were immersed in water at chest level, thus bearing 25% of their body mass. The program included warming up by walking forwards, sideways and backwards through the water in the pool. The program emphasized on: Tone control (child was curled in a ball sideways to the therapist), stretching exercises (child on plinth) (the achilles tendon, hamstrings, flexors and adductors in the lower limb, and the shoulder internal rotators, elbow and wrist flexors and pronators of the upper limb), re-education of righting and equilibrium reactions (in stride sitting position in the latter's lap and horizontal supine float lying), balance facilitation (independent sitting balance, standing balance, weight shift, stroke stand, leg balance exercise with support of the front rails, and standing on balance board), and walking in different directions. After finishing the underwater exercise (duration of session was 60 minutes), the child left the pool and took a shower (25ºC) and remained in the changing room (22ºC) for at least 15 minutes and take a juice before leaving.

For the land-based group:

- The aims of the program directed towards inhibiting abnormal muscle tone and abnormal reflexes and facilitation of normal movement patterns of postural control through reflex inhibiting positions using proximal and distal key points of control.
Aquatic Vs Land-Based Exercises on Balance & Walking

- Training for active trunk extension to improve postural control and balance.

- Balance training from different positions, from quadruped position, kneeling, half kneeling and standing position on mat and tilting board.

- Facilitation of righting and equilibrium reactions to improve postural mechanism via variety of exercises applied on ball and balance board through tilting form different positions in forward, backward and sideways.

- Facilitation of protective reactions by applying fast and large amplitude of stimulus to train saving reactions from sitting on roll, also from standing position by pushing the child to enhance the child to take protective steps either forward, backward or sideways to regain balance.

- Approximation as a proprioceptive training applied in a slow and rhythmic manner for upper limbs, lower limbs and trunk to control spasticity and stimulate the joint mechanoreceptors from semi reclined and quadruped positions.

- Facilitation of reaching, grasping and release according to the child abilities.

- Stretching exercises to maintain the length and the elasticity of the muscles which are liable for shortening especially achilles tendon, hamstrings, hip flexors and adductors of both lower limbs while in the upper limbs; shoulder internal rotators, elbow and wrist extensors, pronators and ulnar deviators.

- Gait training activities also were important elements for balance training including:
  - Sideway, forward and backward walking between the parallel bars in front of a large mirror and walking training using stepper.
  - Training of walking in open environment by placing obstacles across walking tract as rolls of different diameters and wedges of different heights.
  - Training of walking on different floor surfaces (spongy and hard surfaces) on mat, on the floor and on the carpets.

The two groups received the physical therapy treatment program for one hour, three times per week, day after day for three successive months.

GraphPad Prism 5 (Graph Pad Software Inc., La Jolla, CA, USA) was used for data analysis. Data were presented as mean ± standard deviation of the mean (SD). In comparing the changes after the intervention in each group, paired t-test was used and for the difference between the two groups; independent t-test was used for the tested parameters. The significant level of \( p < 0.05 \) was considered significant.

**Results**

The collected data from this study represented the statistical analysis of the Stability Indices (SI) measured by Biodex balance system: Overall, mediolateral and anteroposterior stability indices. And kinematic gait parameters: Step length (m), walking speed (m/sec) and time on each foot (recorded as a percent of gait cycle). Data were obtained from both groups; Aquatic therapy (AQ) group and Land-Based exercise (LB) group before and after three months of treatment.

**Demographic and clinical characteristics of the patients in both groups:**

In AQ group, ten patients were male and five patients were female while in LB group nine patients were male and six patients were female. There were no statistically significant differences in baseline demographic and clinical characteristics between the two groups (Table 1).

In both groups, there were statistically significant improvements in stability indices and gait parameters compared with initial values (Table 2). At the end of treatment, the two exercise programs resulted in improvement in all tested variables (Tables 3,4). But the AQ group had significant improvement more than the LB group (\( p < 0.05 \)) (Table 5). No side effects were observed during the study.

**Table (1): Demographic and clinical characteristics of the patients in both groups (AQ & LB).**

<table>
<thead>
<tr>
<th>Variables</th>
<th>AQ group (n=15)</th>
<th>LB group (n=15)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (M:F)</td>
<td>10:5</td>
<td>9:6</td>
<td>0.704(^a)</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>7.8 (1.14)</td>
<td>7.56 (1.11)</td>
<td>0.563(^b)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>23.64 (2.9)</td>
<td>24.21 (3.1)</td>
<td>0.607(^b)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>121.5 (3.4)</td>
<td>122.3 (3.2)</td>
<td>0.512(^b)</td>
</tr>
<tr>
<td>GMFCS (II:III)</td>
<td>7.8</td>
<td>6.9</td>
<td>0.712(^a)</td>
</tr>
</tbody>
</table>

Values indicated mean (standard deviation).
\(^a\): \( \chi^2 \)-test.
\(^b\): Independent t-test.
Gross motor function classification system level (II-III).
Table (2): Comparison between pre treatment mean values of stability indices and kinematic gait parameters in both groups (AQ & LB).

<table>
<thead>
<tr>
<th>Variables</th>
<th>AQ (n=15) mean ± SD</th>
<th>LB (n=15) mean ± SD</th>
<th>MD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biodek balance parameters:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall SI</td>
<td>3.27±0.32</td>
<td>3.25±0.27</td>
<td>0.02</td>
<td>0.854</td>
</tr>
<tr>
<td>Mediolateral SI</td>
<td>2.29±0.49</td>
<td>2.34±0.57</td>
<td>-0.05</td>
<td>0.798</td>
</tr>
<tr>
<td>Anteroposterior SI</td>
<td>2.56±0.51</td>
<td>2.62±0.34</td>
<td>-0.06</td>
<td>0.707</td>
</tr>
<tr>
<td><strong>Kinematic gait parameters:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS (m/s)</td>
<td>0.30±0.14</td>
<td>0.31±0.15</td>
<td>-0.01</td>
<td>0.851</td>
</tr>
<tr>
<td>SL (cm):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt</td>
<td>0.44±0.08</td>
<td>0.45±0.30</td>
<td>-0.01</td>
<td>0.901</td>
</tr>
<tr>
<td>Rt</td>
<td>0.43±0.14</td>
<td>0.46±0.04</td>
<td>-0.03</td>
<td>0.431</td>
</tr>
<tr>
<td>ST (%):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt</td>
<td>74.67±13.95</td>
<td>73.75±12.77</td>
<td>0.09</td>
<td>0.851</td>
</tr>
<tr>
<td>Rt</td>
<td>25.33±5.1</td>
<td>26.25±7.4</td>
<td>-0.92</td>
<td>0.694</td>
</tr>
</tbody>
</table>

Table (4): Comparison between pre and post treatment mean values of stability indices and kinematic gait parameters within LB group.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre treatment mean ± SD</th>
<th>Post treatment mean ± SD</th>
<th>% of change</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biodek balance parameters:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall SI</td>
<td>3.25±0.27</td>
<td>2.31±0.28</td>
<td>28.92</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Mediolateral SI</td>
<td>2.34±0.57</td>
<td>1.91±0.15</td>
<td>18.37</td>
<td>0.0248*</td>
</tr>
<tr>
<td>Anteroposterior SI</td>
<td>2.62±0.34</td>
<td>1.77±0.41</td>
<td>28.28</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td><strong>Kinematic gait parameters:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS (m/s)</td>
<td>0.31±0.15</td>
<td>0.46±0.12</td>
<td>-48.38</td>
<td>0.0053*</td>
</tr>
<tr>
<td>SL (cm):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt</td>
<td>0.45±0.30</td>
<td>0.62±0.09</td>
<td>-37.77</td>
<td>0.0447*</td>
</tr>
<tr>
<td>Rt</td>
<td>0.46±0.04</td>
<td>0.57±0.16</td>
<td>-21.93</td>
<td>0.0153*</td>
</tr>
<tr>
<td>ST (%):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt</td>
<td>73.75±12.7</td>
<td>64.5±7.4</td>
<td>12.54</td>
<td>0.0214*</td>
</tr>
<tr>
<td>Rt</td>
<td>26.25±7.4</td>
<td>35.5±4.6</td>
<td>-9.25</td>
<td>0.0003*</td>
</tr>
</tbody>
</table>


Table (5): Comparison between post treatment mean values of stability indices and kinematic gait parameters in both groups (AQ & LB).

<table>
<thead>
<tr>
<th>Variables</th>
<th>AQ (n=15) mean ± SD</th>
<th>LB (n=15) mean ± SD</th>
<th>MD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biodek balance parameters:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall SI</td>
<td>3.27±0.32</td>
<td>1.7±0.29</td>
<td>48.01</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Mediolateral SI</td>
<td>2.29±0.49</td>
<td>1.28±0.27</td>
<td>44.1</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Anteroposterior SI</td>
<td>2.56±0.51</td>
<td>1.35±0.31</td>
<td>47.26</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td><strong>Kinematic gait parameters:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS (m/s)</td>
<td>0.30±0.14</td>
<td>0.58±0.16</td>
<td>-93.33</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>SL (cm):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt</td>
<td>0.44±0.08</td>
<td>0.79±0.26</td>
<td>-79.54</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Rt</td>
<td>0.43±0.14</td>
<td>0.76±0.04</td>
<td>-76.74</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>ST (%):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt</td>
<td>74.67±13.95</td>
<td>53.44±11.3</td>
<td>28.43</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Rt</td>
<td>25.33±5.1</td>
<td>46.56±12.2</td>
<td>-83.81</td>
<td>&lt;0.0001*</td>
</tr>
</tbody>
</table>


Table (3): Comparison between pre and post treatment mean values of stability indices and kinematic gait parameters within AQ group.

Discussion

This study attempted to measure the effects of AQ compared to LB interventions on balance and locomotor performance in young children with CP. Children with CP show a mixture of primary and secondary functional restrictions, including (a) Hypertonicity; (b) Decreased range of motion in the extremities during walking; (c) Reduced muscular strength; (d) Insufficient aerobic and anaerobic capacity; (e) Reduced respiratory function. All these factors affect the ability of children with CP to walk, which is a primary rehabilitation concern of parents and clinicians [22].

All the measuring variables of the pre treatment mean values in both AQ and LB groups showed non-significant differences, these findings demonstrated the homogeneity between both groups before starting the study and reflecting the validity of the sample collection and random classification of children between both groups.
The improved post treatment values of the stability indices of the LB group may be caused by the shift of the anticipatory center of pressure and the feedback to maintain balance gained from balancing exercises. This shift may come as a result to the application of exercises that improve body righting and equilibrium such as, higher cortical reactions facilitation (protective, equilibrium, and righting reactions). This comes in agreement with Hay and Redon [23] who reported that in children from 6 to 8 years old, the anticipatory center of pressure shift and the feedback reaction to maintain balance during the motion were more continuous, systematic, and harmonious. In 9 to 10 years old, the anticipatory compensation was shown only when the postural control disturbance reached risky limits.

The improved postural control as seen in post treatment results of the LB group may be caused by improvement in somatosensory system which includes proprioceptive and tactile sensors in which proprioceptive sensors relay messages regarding the position’s of one’s body in space, and the tactile sensors relay information about the feel of the environment. Proprioception has been shown to be a factor in maintaining postural control [24].

The significant improvement obtained in the post treatment mean values of the measuring variables of the AQ group may be attributed to the effect of buoyancy that leads to a reduction in the gravitation forces that act on the musculoskeletal system, allowing for a greater relaxation of muscles that are constantly working against gravity and reduces the force that is placed on the articulating structures. Immersion also improves balance abilities by increasing proprioceptive input to the immersed body and provides it with greater body alignment and stability. Sensory feedback may also increase, thus increases the sensory output to the muscles to contract to stabilize postural alignment because resistance to movement through a viscous fluid like water is greater than resistance through air [25].

The post treatment results of this study support the use of aquatic therapy to work on improving dynamic balance, as the aquatic environment provided in our study was designed for practicing at about 25% body weight rather than at full weight bearing, this comes in agreement with Stevens and Morgan, [26] who stated that partial immersion in water allows participants to work on improving dynamic balance. Land-based harness systems do not require effort to maintain balance, since falling is not an option. In water, however, falling is always a possibility but rarely a danger in well-monitored programs. A fall in water doesn’t occur as quickly as it does on land, and efforts to stay upright while walking in water provide the necessary retraining for the patients.

This is evidenced by a study performed by Resende and Rassi [27] regarding the effects of aquatic balance training on the balancing abilities of elderly women. The researchers used a 12 week low to moderate intensity hydrotherapy program for balance. Balance testing at 6 weeks and 12 weeks showed a significant increase in the elderly women’s balance as well as reduction in the scores in a scale of risks of falls.

Improved gait parameters in form of speed, step length and stance time on one leg that were observed in the AQ group more than the LB group can be attributed to the well trained movements in water without fear of losing balance [28]. Although viscosity limits the speed of power training, the opportunity to try accelerated movement without the fear of falling can be used to practice activities like rising from a chair or stepping up onto a step [29]. This come in agreement with Heitkamp et al., [30] who found that increased strength in aquatic environments comparable to those on land, strength gains may be attributed to an improvement of intramuscular coordination.

Changes in walking speed is usually linked to changes in both step length and cadence, according to Wall et al., [31] who reported that walking speed is a function of both cadence and step length. An increase in either cadence or step length contributes to increased walking speed. In children with CP, decreased joint mobility (mainly during stance) restricts forward motion of the body over the supporting foot, thus affecting gait progression and speed [28]. It was stated that aquatic therapy reliefs hypertonicity in spastic type of CP. The body core temperature increases when the body was immersed in warm water (33º-35ºC) this leads to reduction in gamma fiber activity, which in turn reduces muscle spindle activity, facilitating muscle relaxation and reducing spasticity. Thus, resulting in increased joint range of motion and consequently creating better postural alignment and smoothness of gait transitions.

The strength of our study was a relatively homogeneous selection of patients (GMFCS level II and III). As it is well known that appropriate professional supervision is important for the efficacy of exercise programs, both groups in our study performed exercise under the supervision of a
physiotherapist, which created assurance of compliance, good technique and positive role of therapist reinforcement. The main limitation of our study was the absence of follow-up, so we could not assess long-term effects of treatment. Furthermore, we studied only physical and not psychological and social components of CP, which are known to be important in this condition.

Conclusion:
Based on our findings, both aquatic and land-based training may benefit children with CP by improving balance and locomotion in short term. Aquatic exercise is an appealing form of exercise for children with CP because of the unique properties of water that may reduce risks associated with joint loading and fear of falling, and may allow a child to engage more easily in intensified rehabilitative programs than land-based exercise.

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