An Aquatic Physical Therapy Program at a Pediatric Rehabilitation Hospital: A Case Series

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Purpose: The purpose of this case series is to describe the implementation of an aquatic physical therapy (PT) program at a pediatric hospital and to document improvements in participants’ abilities after PT intervention.

Methods: Four patients with cerebral palsy, juvenile idiopathic arthritis, or Prader-Willi syndrome participated in aquatic and land-based PT intervention. Three of the patients had orthopedic conditions which required limited weight-bearing or low-joint impact during motor activities. A wide range of outcomes were used to assess changes in participation, activity, and body function. When available, minimal detectable change and minimal important difference values were used to interpret data. Results: Clinically significant improvements were documented in functional mobility, walking endurance, range of motion, muscle strength, and/or pain reduction for all 4 patients. Conclusions: Aquatic PT used as an adjunct to land-based PT interventions may be effective in improving outcomes in patients with physical disabilities.

Key words: adolescence, aquatic therapy, arthritis/juvenile, case report, cerebral palsy, child, outcome measurement, physical therapy/methods, Prader-Willi Syndrome, weight-bearing

INTRODUCTION

Therapeutic exercise and functional activity training “on land” are common physical therapy (PT) interventions for children with disabilities. More recently, exercise and activity training “in the water” (ie aquatic PT) are gaining popularity. The properties of the water (buoyancy, resistance, and hydrostatic pressure) can assist the therapist when working on strengthening, balance training, and functional skills training while at the same time providing a fun, motivating, and safe environment. Although aquatic PT intervention has many appealing qualities, information on implementation and effectiveness of aquatic PT for children is limited.
capacity and swimming abilities in 5-year-old to 7-year-old children with CP; however, changes in functional mobility were not measured. In another study which evaluated the effects of a combined aquatic and land-based program, improvements in muscle strength and functional mobility were reported for children and adults with spinal muscular atrophy type II and III. Information about the intervention, outcome measures, and analyses however, was limited, making the results difficult to interpret. More recently, a case-controlled study evaluated the effects of a collaborative physical and occupational therapy aquatic program for infants and young children in early intervention. Significant improvements in gross motor skills on the Mullen Scales of Early Learning were observed in the intervention group as compared to the control group following 24 weeks of once per week aquatic therapy.

Although the potential for effectiveness of aquatic intervention appears strong, studies using aquatic PT intervention for children remain limited in number and study design. Further evidence is needed to assist therapists in designing a plan of care that includes aquatic PT and determining the appropriate intervention dosage (frequency, duration, and exercise intensity). With our aquatic therapy program in its infancy, we did not have enough information or funding to design a randomized control trial but decided to first document current practice and critically evaluate this information. The purpose of this report is to provide information about the development of an aquatic PT program in a pediatric hospital. Information about the use of aquatic PT as a procedural intervention and the use of standardized tests and measures to evaluate outcomes is presented using a series of case descriptions.

**PROGRAM DESCRIPTION**

Franciscan Hospital for Children (FHC) is a pediatric hospital and rehabilitation center and physical therapists provide examination and intervention services to children in all of the hospital programs including inpatient, outpatient, residential, and educational. Aquatic PT services at FHC began in May 2005. In preparation for the implementation of PT services in the aquatic environment, members of the PT department conducted a review of the literature describing aquatic therapy for children. Next, a pool policy and procedure manual was developed based on the pool manufacturer's guidelines, existing hospital policies and procedures, consultation from colleagues at facilities with aquatic programs and professional resource books. The therapists participated in training that included water safety, risk management and emergency procedures, infection control and hydrodynamic principles, and therapeutic techniques for use in the water. New staff members receive a comprehensive orientation and then they must demonstrate competence in specific safety and clinical procedures.

The therapeutic pool at FHC provides an 8 foot by 12 foot treatment area. It features an adjustable floor (variable depths); an underwater treadmill; resistive jets with different levels of intensity; a hand-held massage hose; removable parallel bars; underwater cameras and viewing monitors; and a computer documentation program.

**CASE DESCRIPTIONS**

The majority of children (73%) who use the pool are outpatients so we highlighted 3 outpatient cases and 1 inpatient case. Refer to Table 1 for demographic information.

**Examination**

A full examination was completed for each of the participants and consisted of a parent/child interview to gather information about the family's goals and expectations; chart review to gather pertinent medical information; and a systems review. Several tests and measures covering a range of the World Health Organization International Classification of Function levels were administered to document abilities and progress toward goals. For reexamination purposes, several tests and measures were also administered intermittently during the episode of care to record progress toward goals. For this article, we are highlighting the primary preintervention and postintervention outcome measures described in Table 2.

**Evaluation**

On the basis of the data gathered during the examination process, each physical therapist made clinical judgments determining the child's classification using the PT guide to practice, prognosis, and types of intervention needed. As part of the evaluation, the physical therapist determined that aquatic PT was an appropriate intervention in conjunction with other procedural interventions.

**Case 1** For this child, the musculoskeletal pattern 4D [impaired joint mobility, motor function, muscle performance, and range of motion (ROM) associated with connective tissue dysfunction] was chosen. The prognosis for this child was that she had the potential to regain pain-free ambulation with a symmetrical pattern and resume age-appropriate gross motor development. The long-term goals, as set by the parents and the physical therapist included: (1) Pain-free left knee for all activities, (2) Improve left knee ROM to within normal limits, (3) Improve left quadriceps strength so the child will walk with a symmetrical, age-appropriate pattern, and go up stairs leading with the left lower extremity (LE) and down leading with the right, and (4) advance gross motor skills, such as jumping in place with symmetrical push-off and landing and riding a tricycle. The plan of care was PT for 45 to 60 minutes, 2 times per week, once aquatic-based outpatient, and once land-based through an early intervention program for a total of 6 months. Procedural interventions of left knee stretching, LE strengthening, gait training, and gross motor skills training were used. Parent instruction in a home program focused on stretching, strengthening, and facilitation of gross motor skills. The clinical decision for including water-based activities in this plan of care was that water provided a low-impact environment for joint protection. Hydrostatic pressure of the water environment had the potential to limit knee edema. This child was more

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achieve these specific mobility goals. Procedural interven-
tense program of PT 2 times per week for 5 to 6 weeks to
fewer gait deviations. The plan of care was for a short in-
kick a ball, and walk further with improved efficiency and
strength for child to be able to jump over a small obstacle,
out losing his balance, and (7) improve bilateral leg
standing balance so that child is able to reach further with-
will have a longer step length bilaterally, (6) improve
improve gait pattern so that child will not trip over toes and
siflexion and popliteal angle ROM by 10° or more, (5)
proved efficiency, (4) increase bilateral passive ankle dor-
ance so that he will walk further in 3 minutes with im-
antomic goals for this child in-
community. The specific anticipated goals for this child in-

motivated for her PT sessions in the water and more coop-
ervative during pool activities. Land-based PT in the home
setting focused on parent instruction for a home program
and functional mobility in the home environment.

Case 2. The second child was classified in neuromus-
cular pattern 5C (impaired motor function and sensory
integrity associated with nonprogressive disorders of the
central nervous system—congenital origin or acquired in
infancy or childhood). The prognosis for this child was that
he had potential to improve his gross motor abilities so that
he could participate in play with other children and be
independent and safe ambulating at home and in the com-
munity. The specific anticipated goals for this child in-
cluded: (1) ambulate up and down 2 flights of stairs while
carrying something in his arms, (2) get off the floor quickly
and without using his hands, (3) improve walking endur-
ance so that he will walk further in 3 minutes with im-
proved efficiency, (4) increase bilateral passive ankle dor-
siflexion and popliteal angle ROM by 10° or more, (5)
improve gait pattern so that child will not trip over toes and
will have a longer step length bilaterally, (6) improve
standing balance so that child is able to reach further with-
out losing his balance, and (7) improve bilateral leg
strength for child to be able to jump over a small obstacle,
kick a ball, and walk further with improved efficiency and
fewer gait deviations. The plan of care was for a short in-
tense program of PT 2 times per week for 5 to 6 weeks to
achieve these specific mobility goals. Procedural interven-
tions included gait training, endurance training, gross mo-
tor skills activities, balance training, strengthening, calf
and hamstring stretching, and home exercise program in-
struction. The clinical decision for including water-based
activities in this child’s plan of care was because water
provided a low-impact environment while at the same time
being a highly motivating environment for this child. In
addition, the buoyancy of the water was helpful for work-
ning on calf muscle strengthening in standing.

Case 3. For case 3, the PT classification was deter-
mined to be 4I (impaired joint mobility, motor function,
muscle performance, and ROM associated with bony or
soft tissue surgery) because of the child’s recent orthopedic
surgery and resultant muscle weakness, ROM limitations,
and limited ambulation abilities. The following long-term
anticipated goals were determined by the child, parents,
and therapist and included: (1) independent ambulation
with increased speed to keep up with other children his
age, (2) independent ambulation up and down stairs with-
out a handrail and alternating steps, (3) able to “run” faster
to play informal sports with other children, (4) able to walk
“without limping” (fewer gait deviations), (5) improve
trunk and LE strength to allow for attainment of functional
goals and improve right hip and knee strength to 4/5 and
ankle strength to 2/5, and (6) improve ankle dorsiflexion
ROM to 20° and ankle eversion ROM to 15°. The PT prog-
nosis was that this child could achieve the anticipated long-
term goals with a plan of care which included gait training,
TABLE 2
Tests and Measures and Psychometric Properties

<table>
<thead>
<tr>
<th>Test or Measure</th>
<th>Psychometric Properties (SD = Standard Deviation of Baseline Reliability Data)</th>
<th>MID (points)</th>
<th>MDC₉₀ Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian Occupational Performance Measure (COPM)</td>
<td>Responsive to change¹⁹ Moderate test-retest reliability- performance (ICC = 0.79; SD = 1.67); satisfaction (ICC = 0.75; SD = 1.81)²⁰</td>
<td>Performance ± 1.8 points Satisfaction ± 2.1 points</td>
<td>± 2²¹</td>
</tr>
<tr>
<td>Gross Motor Function Measure-66 (GMFM-66)</td>
<td>Face and construct validity established²¹ Test-retest reliability is high (ICC = 0.99)¹³ and (ICC = 0.88–0.90)²¹ Interrater reliability ranged from (ICC = 0.81–0.90)²² SD = 7.7²³</td>
<td>± 1.79 points</td>
<td>± 1.58²²</td>
</tr>
<tr>
<td>Pediatric Evaluation of Disability Inventory (PEDI) mobility functional skills (FS) and caregiver assistance (CA)</td>
<td>Concurrent validity with Peabody Developmental Motor Scales (r = 0.64–0.95)²⁴ Intrarater reliability for FS Mobility (ICC = 0.98) and for CA Mobility (ICC = 0.98)²⁴ Interrater reliability FS Mobility (ICC = 0.92) and CA Mobility (ICC = 0.90)²⁴ FS Mobility SD = 17.9²⁵</td>
<td>FS Mobility ± 5.9 points CA Mobility NA</td>
<td>± 8.7²⁵ ± 11.2²⁵</td>
</tr>
<tr>
<td>3-min walk and Energy Expenditure Index (EEI)</td>
<td>EEI has been validated for children with CP²⁶ Concurrent validity with Peabody Developmental Motor Scales (r = 0.89–0.94)²⁷ Test-retest reliability for distance walked (ICC = 0.85; SD = 0.40)³¹ Test-retest reliability for EEI (ICC = 0.96; SD = 0.33)²³</td>
<td>Distance = ± 36.2 m EEI = ± 0.15 beats/m</td>
<td>NA</td>
</tr>
<tr>
<td>Observational Gait Scale (OGS)</td>
<td>Acceptable reliability for components: knee and foot position in mid-stance, initial foot contact and heel rise interrater reliability (weighted kappas = 0.43–0.86) and intrarater reliability (weighted kappas = 0.53–0.91)²⁸</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Functional Reach Test (FRT)</td>
<td>Intrarater reliability is high within a single session for children with LE spasticity (ICC = 0.94–0.98)²⁹ Intrarater reliability between sessions (ICC = 0.87; SEM: 3.03)³⁰</td>
<td>± 2.6 cm</td>
<td>NA</td>
</tr>
<tr>
<td>Timed single limb stance</td>
<td>Test-retest reliability data is high for one-leg standing in children with cerebral palsy (ICC = 0.99)³⁰</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Floor to Stand (FTS)</td>
<td>Intrarater reliability for the FTS is high (ICC = 0.89; SD = 15.2 seconds) (S. Haley, M. Fragala-Pinkham, and H. Dumas, unpublished data, 2005)³¹</td>
<td>11.7 sec</td>
<td>NA</td>
</tr>
<tr>
<td>Manual muscle testing (MMT)</td>
<td>Limited reliability information; Modified Medical Research Council Scale, interrater reliability ranged from 0.67 to 0.93 for children ≤15 years with Duchenne’s muscular dystrophy³²</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Isometric muscle strength: hand-held dynamometer (HHD)</td>
<td>High test-retest reliability for LE HHD for children with CP (ICC = 0.90–0.99)³³ Test-retest reliability for knee extensors (KE) ICC = 0.95; SD = 3.3²¹ Test-retest reliability for ankle plantarflexors (AP) ICC = 0.97; SD = 6.2²³</td>
<td>KE = ± 1.71 kg AP = ± 2.48 kg</td>
<td>± 3 points</td>
</tr>
<tr>
<td>Passive range of motion (ROM)</td>
<td>Moderate to high intrarater reliability for children with spastic diplegia Dorsiflexion (DF) ICC = 0.63–0.69; SD = 5.6³⁴ Popliteal angle (PA) ICC = 0.57–0.76; SD = 6.2³⁴ Knee extension (KE) ICC = 0.89–0.92; SD = 2.4³⁴ Interrater reliability Kappa 0.52 (face):0.82 (cry)³⁵ High test-retest reliability (r = 0.80–0.883; SD = 2.8)³⁶³⁷</td>
<td>DF = ± 8.2° PA = ± 9.4° KE = ± 4.5°</td>
<td>NA</td>
</tr>
<tr>
<td>Face, Legs, Activity, Cry and Consolability (FLACC)</td>
<td>Valid and responsive measure of pain in young children and also for older children with cognitive impairment³⁵,³⁶ Interrater reliability Kappa 0.52 (face):0.82 (cry)³⁵ High test-retest reliability (r = 0.64; SEM = 1.3)³⁹</td>
<td>± 2.25–2.9 points</td>
<td>NA</td>
</tr>
<tr>
<td>Numerical Pain Scale</td>
<td>Valid measure of pain in adolescents and adults³⁶,³⁹ Moderate test-retest reliability (r = 0.64; SEM = 1.3)³⁹</td>
<td>± 3 points</td>
<td>NA</td>
</tr>
<tr>
<td>Juvenile Arthritis Quality of Life Questionnaire (JAQQ)</td>
<td>Face and content validity confirmed³⁰ Responsiveness established for 2–18- yrs-old children with JIA³⁰,³¹</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
gross motor skill training, LE strengthening, electrical stimulation to right ankle dorsiflexors and evertors, stretching and soft tissue mobilization for right ankle, and instruction and routine update of the home exercise program. The estimated length of PT services was 2 times per week for 1 to 2 months and 1 time per week for 3 to 4 months for a total of 4 to 6 months. The clinical decision was made to include a combination of water and land-based interventions. Land-based therapy was needed to focus on active ankle movements using electrical stimulation and to work on progressive ambulation on level surfaces and stairs eventually without the short leg cast. Water-based intervention was chosen because of the buoyancy and limited weight-bearing forces so that this patient could work on gait training using a more symmetrical pattern with emphasis on increased right LE stance time even with weight-bearing restrictions. This patient’s course of intervention was complicated by a fall at home resulting in a right femoral neck fracture and surgical pinning 2 months after foot surgery and 1 month after he started receiving outpatient PT services. One week after the surgical pinning of the right hip, this patient resumed outpatient PT and was seen for a reevaluation. At that time it was determined that an additional 2 to 3 months of PT services was needed to attain long-term goals. The clinical decision was made to continue with a combination of water and land-based interventions. Land-based therapy was needed to focus on active ankle movements using electrical stimulation and to work on ambulation on level surfaces and stairs with a device and eventually progressing to full weight-bearing gait training on land without a device. Water-based intervention was used so that this patient could continue to work on gait training without a device in the water using a symmetrical walking pattern. Ambulation in chest height water was allowed 2 weeks after the hip surgery when the incision site was sufficiently healed. In addition, this child had a pool in his backyard, enjoyed swimming activities, and requested aquatic PT services and the physical therapist felt that this would assist with motivating this child to participate in upright standing activities in water, aquatic therapy was initiated. Frequency was increased to 1 to 2 times per day for 5 to 6 days per week for 30 to 45 minutes per session because the patient was making daily progress and appeared to be benefiting from intensive therapy. Treatment activities included sit-stand transfers, as well as active ROM exercises of all 4 extremities while in a standing position in the water. Treatment interventions in the water were chosen based on the mechanics of the spine, with the general goal of unloading the spine while strengthening all musculature. Interventions in the pool were eventually progressed to ambulation on a stable surface, then to ambulation on an unstable surface (pool treadmill). As her weight-bearing status progressed, water depth was gradually decreased, subsequently increasing the load on the patient’s spine. As bone healing occurred and strength and endurance improved, standing and walking activities on land were added to her program. Initial short-term goals included achieving independence with bed mobility and repositioning, as well as independence with transfers in/out of bed to a wheelchair. Long-term goals included achieving independence with standing and ambulation household distances.

**Intervention**

Episodes of care ranged from 6 weeks to 8 months. Frequency and procedural interventions are provided in Table 3.

**Outcomes**

To determine clinically significant changes in outcomes, we report minimal detectable change (MDC) and minimal important difference (MID) values when information is available. We calculated MDC for all of the tests and measures for which we could find relevant test-retest information and baseline standard deviation data. MDC is defined as the magnitude of change over and above measurement error of 2 repeated measures at a specified confidence interval.11 For this report, we have chosen a confidence interval of 90% which is acceptable for clinical data from individual patients.12 MID is another way to determine the amount of change needed on a specific measure to demonstrate a clinically significant change in function as defined by the patient, family, and/or therapist.11 Table 2 contains MDC and MID values. The outcome data for cases 1 to 4 are in Tables 4–7 and summarized below.

**Case 1.** Clinically significant improvements in Juvenile arthritis quality of life questionnaire scores and left knee ROM were documented for this patient at the end of the 6-month intervention period. Increased left knee extension passive ROM allowed for greater knee extension and increased weight-bearing on the left LE during gait.
### Case 1
**Pool-1x/wk for 4-6 mo**
**PT visits were home 1x/wk for 60 min**
**Early intervention**

**Frequency/Duration**
- 1x/wk for 4-6 mo

**Procedural Interventions**
- Squat to stand in water at hip height (30% weight bearing (WB))
- Gait training on underwater treadmill, 50% WB, 0.4 mph; focus on left knee extension during terminal swing, initial contact, mid and terminal stance
- Shuttle running
- Jumping in place with emphasis on bilateral pushoff
- Step ups with focus on leading with left leg
- Walking into the jets at 50% WB with jet intensity of 30%
- Active/passive ROM to left hamstrings, mother instructed in home stretching program to be done in warm tub during nightly bathing

**Progressions**
- Squats: ↑ repetitions, ↓ water depth (75% WB)
- Treadmill-advanced to run at 2.0–2.2 mph with symmetrical pattern
- Shuttle Run- ↑ distance before stopping and ↑ speed
- Jumping- ↑ repetitions, ↑ speed
- Step-ups- ↑ repetitions, ↓ water depth
- Walking- ↑ jet intensity to 50%

**TABLE 3**

<table>
<thead>
<tr>
<th>Frequency/Duration</th>
<th>Procedural Interventions</th>
<th>Progressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1 Pool-1x/wk for 4-6 mo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early intervention</td>
<td>Squat to stand in water at hip height (30% weight bearing (WB))</td>
<td>Squats: ↑ repetitions, ↓ water depth (75% WB)</td>
</tr>
<tr>
<td>PT visits were home 1x/wk for 60 min</td>
<td>Gait training on underwater treadmill, 50% WB, 0.4 mph; focus on left knee extension during terminal swing, initial contact, mid and terminal stance</td>
<td>Treadmill-advanced to run at 2.0–2.2 mph with symmetrical pattern</td>
</tr>
<tr>
<td></td>
<td>Shuttle running</td>
<td>Shuttle Run- ↑ distance before stopping and ↑ speed</td>
</tr>
<tr>
<td></td>
<td>Jumping in place with emphasis on bilateral pushoff</td>
<td>Jumping- ↑ repetitions, ↑ speed</td>
</tr>
<tr>
<td></td>
<td>Step ups with focus on leading with left leg</td>
<td>Step-ups- ↑ repetitions, ↓ water depth</td>
</tr>
<tr>
<td></td>
<td>Walking into the jets at 50% WB with jet intensity of 30%</td>
<td>Walking- ↑ jet intensity to 50%</td>
</tr>
<tr>
<td></td>
<td>Active/passive ROM to left hamstrings, mother instructed in home stretching program to be done in warm tub during nightly bathing</td>
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</table>

### Case 2
**2x/wk for 60 min for 6 wks (Total of 8 pool sessions and 4 land sessions)**

**Land-outpatient visits**
- Tricycle riding on level, smooth surfaces – initially needed moderate assistance (Rode tricycle from PT area to pool area before and at the end of pool sessions.)

**Procedural Interventions**
- Kicking activities with 2 pound ankle weight using kick board
- Toe raises and heel raises in chest deep water
- Balance activities, water at chest height: 1) unilateral stance, water jets at 14%, 2) jumping, 3) hopping, 4) skipping
- Gait training on treadmill focusing on initial contact with a heelstrike and knee extension during initial contact and mid stance at 1.5 – 2.2 mph for 2 min increments for total of 8 min
- Running/sprinting on underwater treadmill, water at hip height
- Swimming above and under water against jets
- Active/passive stretching for hip flexors and adductors, hamstrings, and ankle plantarflexors at end of session
- Land-outpatient visits
- Tricycle riding on uneven surfaces, longer distance before stopping, progressed to no assistance needed

**Progressions**
- Kicking-5 pound weight by Wk 5
- Toe / heel raises –waist to knee deep water and ↑ repetitions
- Balance activities, water waist to knee deep.
- Unilateral stance with jet intensity progressing to 50% and knee deep water
- Treadmill walking/running,- ↑ speed and for longer periods without a rest. 2.2–3.2 mph for 4 min increments for up to 20 min. Side shuffles, braiding and backward walking on treadmill.
- Swimming: ↑ jet intensity from 25%–70%
- Less assistance provided for stretching

### Case 3
**2x/wk for 60 min for 2½ mo and then 1x/wk for 60 min for 5½ mo. 76% of the PT visits were pool sessions**

**Land-outpatient visits**
- Tricycle riding on level, smooth surfaces – initially needed moderate assistance (Rode tricycle from PT area to pool area before and at the end of pool sessions.)

**Procedural Interventions**
- Strength training-10 repetitions of bilateral leg exercises in standing using water resistance (hip flexion, front and back and side straight leg kicks; knee flexion with hip extended; ankle plantarflexion and dorsiflexion, wall squats, kicking in prone)
- Standing balance training using resistance from the jets
- Sitting on pool board and maintaining position while therapist tilts board
- Gait training using pool floor and treadmill, water at chest height and focusing on gait pattern-longer step length on left, increased stance time on right, initial contact with heel bilaterally
- Cardiorespiratory endurance activities-treadmill walking, 0.8 – 1.5 mph for 1–2 min increments for 6 min total
- Swimming with floatation device, cues to use right UE and LE
- Active movement and strengthening of right plantarflexor, dorsiflexor, and evertor muscles using electrical stimulation in sitting
- Progressive resistive exercises (PREs) for lower extremities bilaterally-10 repetition maximum resistance; 1 set of 10 repetitions
- Trunk strengthening using a therapeutic ball and floor exercises
- Gait training on level surfaces and stairs using a platform walker, uneven terrain, and stairs, balance training
- Home exercise program instruction of stretching, use of short leg night cast to maintain passive range of motion, and PREs (hip extensors, adductors, quads, hamstrings)

**Progressions**
- Strength training: ↑ repetitions (2–3 sets of 15 repetitions); ↑ resistance (2–5 lb ankle weights)
- Standing balance activities-added unilateral stance activities; ↑ jets to 50%
- Balance board activities to increase balance reaction speed and trunk strength in sitting and kneeling
- Gait training on treadmill with water waist height with fewer verbal cues; ↑ treadmill speed for fast walking and running (2.2–4.2 mph); ↑ walking speed and time to 15–22 min without rest
- Step ups on 4 and 8 inch steps; ↑ repetitions; ↓ water height
- Swimming without floatation against jet resistance; fewer cues to get right arm out of water and kick right leg
- Electrical stimulation right plantarflexor, dorsiflexor, and evertor muscles during gait
- PREs- ↑ 2–3 sets of 10 repetitions; ↑ amount of weight
- Therapeutic exercises ↑ difficulty, repetitions, and time of exercise without rest
- Gait training on stairs and uneven surfaces; running activities
- Update home exercise program

(Continued)
Improved left knee extensor strength and left knee ROM appeared to positively influence her dynamic standing balance and gross motor skills. She continued to master age-appropriate motor skills, such as climbing stairs using a reciprocal pattern, running with a symmetrical pattern, and riding a tricycle. Pain did not increase during this episode of care even though activity level increased. Of a possible 24 weekly sessions, this childattained 100% program attendance for this child.

Case 2. During this short-term 6-week intensive PT program, this patient made clinically significant improvements in gross motor function, balance, LE ROM, and on 2 strength measures. On the Canadian Occupational Performance Measure, his parents reported improvements on the following goals: (1) walk up and down stairs while carrying something in his arms, (2) run faster without falling, and (3) get off the floor with less effort and without using his arms. For the 3-minute fast walk test, this patient walked faster and had a lower energy expenditure index after the intervention. Program attendance for this child was 100%.

TABLE 4
Outcome Data for Case 1

<table>
<thead>
<tr>
<th>Measures</th>
<th>Initial</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAQQ—gross motor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw score</td>
<td>27</td>
<td>17</td>
</tr>
<tr>
<td>Mean score</td>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>FLACC pain scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate activity</td>
<td>4/10</td>
<td>0/10*</td>
</tr>
<tr>
<td>4 hrs after moderate activity</td>
<td>2/10</td>
<td>0/10</td>
</tr>
<tr>
<td>MMT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left knee extensors</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Right knee extensors</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Passive ROM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left knee extension</td>
<td>−20°</td>
<td>−7**</td>
</tr>
</tbody>
</table>

*Value greater than MDC.

Case 3. This patient’s course of intervention was complicated by a fall and resultant right femoral neck fracture and surgical pinning. His right LE weight-bearing status regressed from weight-bearing as tolerated with short leg cast to non–weight-bearing. Regardless of the weight-bearing restrictions on land, he continued with gait training activities in the pool, as cleared by his orthopedist. At discharge from PT services, this child made clinically significant improvements on the Pediatric Evaluation of Disability Inventory, Floor to Stand, passive ankle ROM, and 3-minute fast walk. His parents also reported improvements on all of the Canadian Occupational Performance Measure goals. They suggested that his progress with walking skills was faster because he was able to practice walking in the pool even though he could not walk on land due to difficulty adhering to the weight-bearing precautions while his right hip

TABLE 5
Outcome Data Case 2

<table>
<thead>
<tr>
<th>Measures</th>
<th>Initial</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>1.3</td>
<td>7.7*†</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>3</td>
<td>8*†</td>
</tr>
<tr>
<td>GMFM-66 (scaled score)</td>
<td>69.22</td>
<td>76.75*†</td>
</tr>
<tr>
<td>OGS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L 6/22</td>
<td>L 10/22</td>
<td></td>
</tr>
<tr>
<td>R 8/22</td>
<td>R 13/22</td>
<td></td>
</tr>
<tr>
<td>3-min fast walk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EEI (beats/min)</td>
<td>1.02</td>
<td>0.85*</td>
</tr>
<tr>
<td>Distance (m)</td>
<td>274.3</td>
<td>327.36*</td>
</tr>
<tr>
<td>Standing functional reach (cm)</td>
<td>23</td>
<td>29.5*</td>
</tr>
<tr>
<td>Peak isometric strength (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee extensors</td>
<td>L 14.8 R 14.0</td>
<td>L 16.6* R 16.2*</td>
</tr>
<tr>
<td>Ankle dorsiflexors</td>
<td>L 2.2 R 2.2</td>
<td>L 3.3 R 3.6</td>
</tr>
<tr>
<td>Ankle plantarflexors</td>
<td>L 13.5 R 14.3</td>
<td>L 17.3* R 16.2</td>
</tr>
<tr>
<td>Passive ROM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Popliteal angle</td>
<td>L 54° R 48°</td>
<td>L 40°* R 35°*</td>
</tr>
<tr>
<td>Ankle DF</td>
<td>L −5° R 5°</td>
<td>L 6°* R 10°</td>
</tr>
</tbody>
</table>

*Value greater than MDC.
†Value greater than MID.
fracture was healing. Program attendance for this child was 72% over the 8-month episode of care with over half of the cancelled appointments due to other medical appointments. Other cancellations were due to vacations or illnesses.

**Case 4.** For the first 8 weeks, this adolescent had orthopedic restrictions which limited her participation in PT to active and passive arm and leg exercises in bed. Beginning at week 9, she was progressed to partial weight-bearing activities in the pool, but not on land. By week 12, she was able to begin brief, weight-bearing on land via stand-pivot transfers, and by week 14 she was able to initiate upright ambulation on land. At discharge, this patient was independent with household ambulation, and required close supervision for ambulation within the community. She was able to ambulate indoors without the use of

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**TABLE 6**

Outcome Data Case 3

<table>
<thead>
<tr>
<th>Measures</th>
<th>Initial</th>
<th>Week 5: Reexamination After Hip Fracture</th>
<th>Week 20: Reexamination Progressed to Full WB</th>
<th>Right 3 Sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>1</td>
<td>NT</td>
<td>4.5</td>
<td>6.25††</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>1</td>
<td></td>
<td>6.25††</td>
<td></td>
</tr>
<tr>
<td>PEDI mobility functional skills scaled score</td>
<td>38.2</td>
<td>20.9</td>
<td>85.2††</td>
<td>94.2††</td>
</tr>
<tr>
<td>Floor to stand</td>
<td>Needed assistance to get off the floor</td>
<td>Unable</td>
<td>5 mo: 23 sec</td>
<td>10.1 sec*</td>
</tr>
<tr>
<td>3-min fast walk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EEI (beats/min)</td>
<td>1.77</td>
<td>Unable</td>
<td>0.93</td>
<td>0.66*</td>
</tr>
<tr>
<td>Distance (m)</td>
<td>128</td>
<td></td>
<td>253</td>
<td>458§</td>
</tr>
<tr>
<td>Timed single limb stance MMT right</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip abductors</td>
<td>3–</td>
<td>2–</td>
<td>3</td>
<td>4–</td>
</tr>
<tr>
<td>Hip extensors</td>
<td>3–</td>
<td>≥3</td>
<td>4</td>
<td>4†</td>
</tr>
<tr>
<td>Knee extensors</td>
<td>4–</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ankle dorsiflexors</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Ankle plantarflexors</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ankle invertors</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Ankle evertors</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Passive ROM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right ankle DF</td>
<td>5°</td>
<td>5°</td>
<td>12°</td>
<td>20°*</td>
</tr>
<tr>
<td>Ankle eversion</td>
<td>5°</td>
<td>5°</td>
<td>3°</td>
<td>10°*</td>
</tr>
</tbody>
</table>

*Value greater than MDC.
†Value greater than MID.

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**TABLE 7**

Outcome Data Case 4

<table>
<thead>
<tr>
<th>Measures</th>
<th>Week 1</th>
<th>Week 9</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEDI mobility FS scaled score</td>
<td>0</td>
<td>41.4</td>
<td>65††</td>
</tr>
<tr>
<td>PEDI mobility CA scaled score</td>
<td>0</td>
<td>47.2</td>
<td>66.7††</td>
</tr>
<tr>
<td>Walking endurance</td>
<td>Unable to walk on land</td>
<td>Walked 40 feet in pool in shoulder deep water (25% WB)</td>
<td>Walked in pool (25% WB) at 1.2 mph for 25 min (0.49 miles) Ambulated on land for 20 min for 350 ft × 2 repetitions with rolling walker (0.13 miles) Ambulated on land without walker with contact guard × 700 ft in 20 min (0.13 miles)</td>
</tr>
<tr>
<td>Numerical Pain Scale</td>
<td>Passive and active movement: 5/10</td>
<td>Ambulation in pool: low back 2/10; left LE 0/10</td>
<td>Passive and active movement: 0/10* Ambulation land and pool: 0/10</td>
</tr>
<tr>
<td>Timed single limb stance</td>
<td>Not tested secondary to orthopedic restrictions</td>
<td>L = 0 sec R = 0 sec</td>
<td>L = 1 sec with 2 hands held assistance R = 3 sec with 2 hands held assistance</td>
</tr>
<tr>
<td>MMT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip abductors</td>
<td>L 1 R 3†</td>
<td>L 2 R 3†</td>
<td>L 3 – R 4</td>
</tr>
<tr>
<td>Hip extensors</td>
<td>L 1 R 3</td>
<td>L 2 R 3†</td>
<td>L 2 R 3†</td>
</tr>
<tr>
<td>Knee extensors</td>
<td>L 2 R 3</td>
<td>L 3 R 3†</td>
<td>L 3 – R 4</td>
</tr>
<tr>
<td>Ankle dorsiflexors</td>
<td>L 3 R 3</td>
<td>L 3 R 3†</td>
<td>L 5 R 5</td>
</tr>
<tr>
<td>Ankle plantarflexors</td>
<td>L ≥3 R ≥3</td>
<td>L ≥3 R ≥3</td>
<td>L 3 R 4</td>
</tr>
</tbody>
</table>

*Value greater than MDC.
†Value greater than MID.
her walker, and used the walker for community distances. In addition to the above clinically significant improvements in functional mobility, she was also more cooperative and independent in initiating self-movement. She improved her walking endurance, LE strength, and was pain free by discharge from inpatient rehabilitation. Program attendance for this adolescent was 100%.

**DISCUSSION**

The 4 cases presented in this article provide an illustration of combined land-based and water-based PT intervention where 50% or more of the PT sessions were conducted in the pool. All 4 patients demonstrated improvements in impairment level measures such as ROM, strength, balance, or pain reduction as well as improvements in functional mobility or motor skills. Though the ages, diagnoses, and goals differed for each case, the physical therapists believed that a combination of land-based and water-based intervention would assist with carryover of functional mobility skills on land. The results of these reports support previous case reports and other studies indicating that children with restrictions in activity limitations as well as impairments may benefit from aquatic PT intervention.

Across these 4 cases, the use of the underwater treadmill for promoting endurance, improved gait pattern and functional skills appeared to be a successful intervention activity. Improvements in walking speed, distance walked or functional skills have been reported for children with CP who participated in partial weight treadmill training on land. Land-based strengthening exercises have also been shown to be effective in improving strength and function in children with CP, Prader-Willi syndrome, and Juvenile idiopathic arthritis. For these 4 cases, active exercises with resistance of cuff weights and/or water were used to promote LE strength. Findings from other studies indicate that using aquatic resistive exercise can improve strength in children with CP.

Balance activities with water at varying water depths can be used to work on balance especially for children who are fearful about losing their balance. Success performing challenging balance tasks and gross motor skills in the water can potentially increase confidence and lead to less resistance, to try difficult tasks on land. An example of this, is case 3, who was initially hesitant to walk on land for fear of foot pain but was able to walk longer distances and run in the water much sooner than on land. During walking and running activities, the buoyancy of the water reduced LE weight-bearing forces and it also helped us to determine that difficulty with running was due to impaired strength and balance and not deficits in motor control and coordination.

Program attendance was high for all 4 children. This is consistent with what PT staff anecdotaly report; the number of missed appointments (cancellations or “no shows”) is reduced when a child’s PT program includes aquatic intervention. In addition, therapy staff members report a high degree of motivation from the children and youth treated in the water and a decline in behavior-related obstacles to accomplishing therapeutic activities.

For these 4 cases, physical therapists used a wide variety of valid and reliable measures encompassing the multiple levels of functioning depending on the individualized needs of the child. Upon review of the cases, we acknowledge that other measures could have been used to strengthen the documentation and reporting of outcomes. At present, we do not have a standard battery of tests to assess impairment, activity, and participation level outcomes and therefore it makes it difficult to directly compare and contrast the efficacy of different interventions. Although we feel that it is important for therapists to use their clinical judgment and determine what important outcomes are for each child, a general battery of tests may be helpful to guide clinical practice, particularly in a new program. In addition, as more information becomes available on psychometric properties of tests and measures, the use of MDC and MID to evaluate the outcomes on a program wide basis or for individual patients will become feasible.

For the 4 cases presented, PT examination components were not altered even if part of the intervention was anticipated to occur in the water. Examinations were individualized and a combination of participation, activity, and impairment measures were used. Therapeutic activities including strengthening, balance training, cardiorespiratory endurance training, and gait training were still the primary procedural interventions that were used during aquatic PT sessions.

A limitation of this case series is that all 4 patients received both land-based and aquatic-based PT interventions; therefore, improvements in impairment, activity, and participation level measures may be a result of interventions which were land-based, water-based, or a combination of both. Further research is needed to compare the effects of these interventions in order to definitively tease out which improvements can be attributed to aquatic PT.

After reviewing these cases, several questions have surfaced that we would like to evaluate further. Can children with CP and other disabilities improve walking endurance and exercise capacity after participating in an aquatic aerobic exercise program? Do children and families have higher levels of satisfaction and increased motivation to participate in aquatic PT than land-based PT? Do children gain mobility skills, endurance, and strength sooner after orthopedic surgeries if they participate in aquatic PT intervention soon after surgery while they have limitations in weight-bearing? It would also be helpful to evaluate the long-term effects on joints of exercising in the low-impact environment of water rather than the higher impact forces on land. As a result of this work, several additional projects were initiated including the evaluation of aquatic PT using a single subject ABA design and a group aquatic exercise program using a quasi-experimental design in a community pool.

Since the initiation of aquatic therapy services in 2005, the response from referral sources, children and families, and therapy staff has been positive. To date, there
have been no reported injuries or safety incidents. The pool is used by physical and occupational therapists with patients in all hospital programs but outpatient aquatic PT referrals are the highest and continue to increase. Minor logistical problems have been encountered. The demand for aquatic therapy appointments is high and has generated some scheduling conflicts, which have been resolved by extending appointment times into the evening hours. Therapists have noted that documenting patient response to treatment during the session is challenging.

CONCLUSION
An aquatic PT program has been a successful addition to a pediatric rehabilitation hospital PT program. On the basis of the 4 cases, we have presented aquatic PT programs in conjunction with land-based PT intervention may help to improve participation, activity, and function in young patients with varying types of physical disabilities. Further research is needed to determine the effectiveness of individual aquatic PT interventions for young patients with disabilities.

ACKNOWLEDGMENTS
The authors thank the children and their families for participating.

REFERENCES


