

Aquatic Therapy During Acute Rehabilitation for a 4-year-old Boy with Traumatic Brain Injury

A Case Report

Laura Keyser, PT, MS

DPT Candidate

UCSF/SFSU Program in Physical Therapy



SAN FRANCISCO
STATE UNIVERSITY



Significance

- TBI is primary cause of death & injury in pediatric population
- Incidence = 475,000 children per year
\$1 billion in annual hospital costs ¹⁻³
- Injuries range mild - severe according to Glasgow Coma Scale (GCS)⁴
Determined by amount of force inflicted & location of brain affected
 - Mild >12
 - Moderate 9-12
 - Severe <8

Common Impairments

- Primary:
 - Hematoma, cerebral effusion, elevated ICP, anoxia, ischemia
- Secondary:
 - Abnormal muscle tone, postural control & gait
 - Decreased strength, agility, coordination, endurance
 - Deficits in visuospatial control, memory & executive function⁵⁻⁷



Physical Therapy Interventions

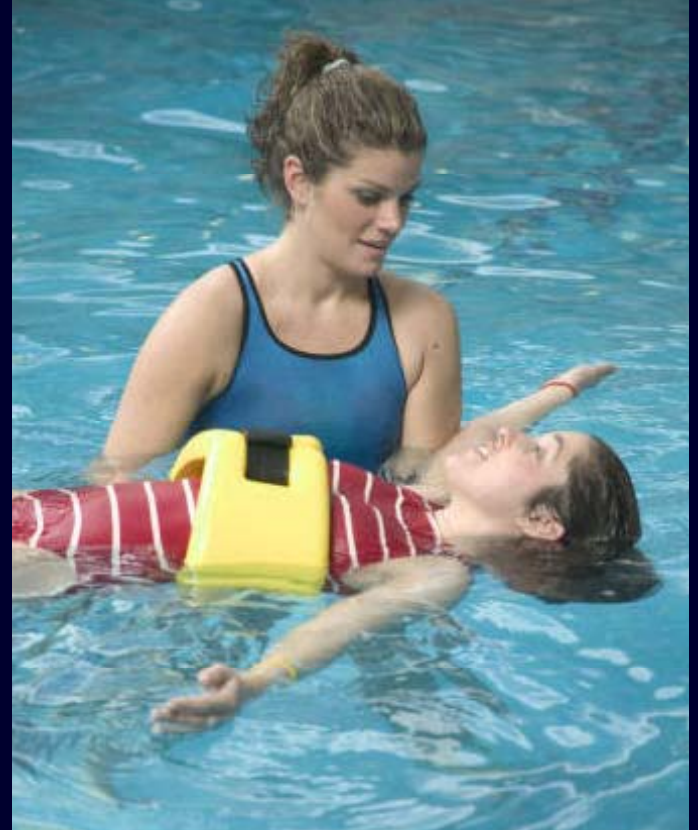
- Functional mobility training:
 - Hands-on facilitation of movement (*i.e.* NDT)
 - Task-specific: standing, wt. shifting, stepping⁶
 - Partial body-weight supported ambulation¹¹
 - Greater intensity of training \Rightarrow better outcomes
- Patients with severe TBI lack physical, cognitive or behavioral requirements to endure multiple PT sessions of adequate duration^{9,10,12}

Clinical Problem

- Children with TBI require intensive rehab
- Severity of cognitive & motor deficits limit tolerance & ability to actively participate in PT
- Aquatic therapy may be a useful adjunct to allow for early mobility among this population
- Literature & guidelines are lacking

Aquatic Therapy (AT)

- **Definition:**
 - An active intervention that utilizes principles of hydrostatics & hydrodynamics to design interventions to target specific impairments & functional limitations



Aquatic Therapy (AT)

- **Populations:**

- Children: rheumatic diseases, CP & DD
- Adults: orthopedic injuries, arthritis, TBI

- **Improvements:**

- Vital capacity & respiratory health
- Extremity strength, ROM, postural control
- Functional mobility & quality of life ^{15,17,20-25}

Properties of Water 13-19

Physical Properties	Effect on the Body
Buoyancy	<ul style="list-style-type: none">-Inc. trunk support & postural control-Assists upward mvmt of extremities-Resists downward mvmt
Immersion	<ul style="list-style-type: none">-Controls degree of wt. bearing-Inverse relationship
Viscosity/ Fluid dynamics	<ul style="list-style-type: none">-Provides resistance to mvmt-Allows for strengthening

Properties of Water 13-19

Physical Properties	Effect on the Body
Hydrostatic Pressure	<ul style="list-style-type: none">-Promotes deep breathing & improves pulmonary function-Provides sensory stimulation-May normalize some sensory deficits
Temperature	<ul style="list-style-type: none">-Neutral warmth relaxes spastic muscles-Inc. soft tissue extensibility & ROM

Aquatic Therapy Evidence

- Children with CP

- Intervention group: AT & Land-based PT
- Control group: Land-based PT only
- Significant improvements in VC & water orientation skills²⁶

- Infants in NICU

- Intervention group: AT techniques
- Control group: Warm water immersion only
- AT group able to maintain a quiet alert state with less physiologic abnormalities²⁷

Aquatic Therapy Evidence

- **Pediatric case reports**

- 14 yo with CP

- ROM, balance, motor planning, coordination, use of hemiparetic UE, ADLs, self-image²⁸

- 12 mo with SMA

- Strength, wt. gain, active mvmt out of water, decreased fear of bathing²⁸

- **Adults with TBI**

- Improvements in self-concept, self-esteem, motivation & health-promoting behaviors^{13,16}

Purposes of the Case Report

1. To describe the deficits seen in a 4-year-old boy with a TBI amenable to the use of AT for gait training
2. To describe the exam & treatment planning for the use of AT as an adjunct to land-based gait training
3. To document the changes observed during the course of treatment



Relevance to Physical Therapy



- Assist pediatric PTs in identifying pts who may benefit from AT
- Provide background for treatment planning for AT interventions
- Offer an alternative for achieving early mobility and meeting functional mobility goals

Case Description

HPI

- 4 yr-old boy sustained TBI when he fell from a bunk bed onto tile floor
- Fx R temporal bone; developed large epidural hematoma
- Presented to ED within 2 hrs with GCS of 3/15

Medical & surgical management

- Emergency craniotomy & craniectomy with duroplasty
- Pentobarbitol-induced coma for days
- Intubated for 3 weeks

Parental consent; records accessed according to HIPPA

Case Description

MRI:

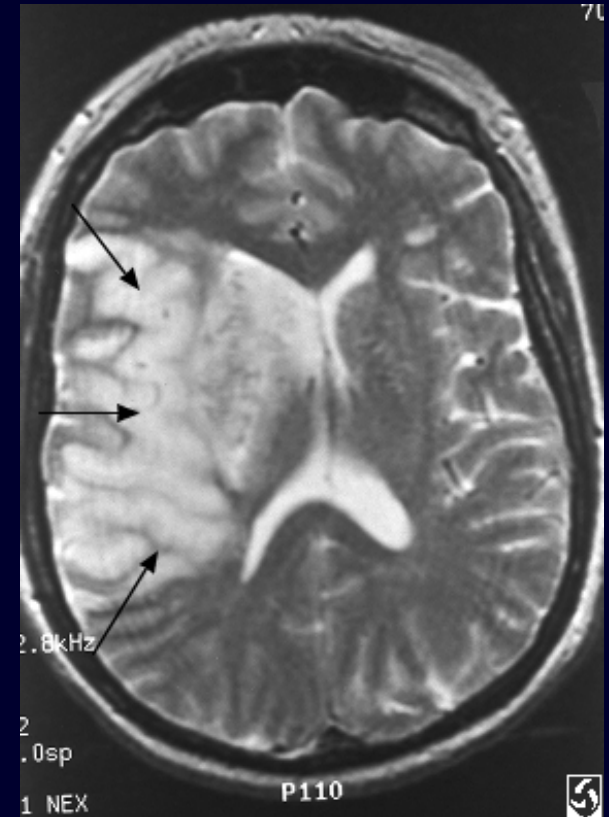
Extensive right cerebral hemisphere infarct in temporal & parietal regions and bilateral basal ganglia lesions

MD Dx:

Left hemiplegia, aphasia, dysphagia

Chief Complaint:

Impaired mobility



Initial Examination

- Functional Independence
 - Determined by level of assistance required to perform functional tasks; based on FIM
 - Dep \Rightarrow Max/Mod/Min \Rightarrow CGA/SBA \Rightarrow Mod I/Ind
 - Kappa = 0.79 - 0.90 ³⁴
 - **Max A for transfers (sup \leftrightarrow sit; sit \leftrightarrow stand)**
 - **Max A for sitting & standing balance**
 - **Dependent for gait**

Initial Examination

- Observational Analysis
 - Direct observation of trunk & limb movements during transitions, ambulation & play activities
 - ICC = 0.65 - 0.85 ³⁵
 - **Poor postural control; unable to maintain midline**
 - **Hypertonic L side; UE posture in flexor pattern**
 - **No active movement L side**
 - **Moves R UE & LE against gravity; full ROM**
 - **↓ Initiation for all functional mobility**
 - **↓ Wt. bearing; knees buckle in standing**

Initial Examination

- Walking Endurance
 - Gait distance
 - Good concurrent validity for distance & O2 uptake
 - **0 ft.**
- Activity Tolerance & Participation
 - Attention & behaviors during PT; Cognitive function tracked by SLP
 - **Labile; frequent crying; irritable to handling**
 - **Attends to task for 10 min with max cues**
 - **Requires multiple rest periods**
 - **Rancho level 4-5: Confused & Agitated**

Plan of Care

Mobility	Problems	Initial Goal
Bed mobility & Transfers	Requires Max A Decreased initiation Poor trunk control	Independent
Gait	Dependent Hypertonic L side; No active mvmt	Independent x short community distances with AD
Stair Climbing	Unable to perform	Supervised with HR

Plan of Care

- **Pre-gait Training**

- Weeks 1-4
- **Rx focus:** Trunk/pelvic stability; Balance; Transitions; Activity tolerance

- **Initial Gait Training**

- Weeks 4-5
- **Rx Focus:** gait training; weight bearing & stepping

- **Aquatic Therapy**

- Weeks 6-8
- **Rx Focus:** pt. motivation; increase active movement & initiation; gait training

Pre-Gait Training (Weeks 1-4)

Interventions	Rationale
Stretching; serial casting & splint fabrication; <i>Baclofen</i>	Diminish tone; Maintain ROM
Static & dynamic play activities in sitting, standing & developmental positions	Strengthen trunk to improve balance & stability



Pre-Gait Training (Weeks 1-4)

Interventions	Rationale
Facilitation of functional mobility	Implicit learning via facilitated movements; encourage movement initiation
Use of quiet room to reduce auditory & visual stimuli	Allow pt. to focus on motor tasks



Pre-Gait Training (Weeks 1-4)

Pt. Response:

- ↑ Trunk strength; head in midline
- ↑ Sitting balance
- ↑ Movement initiation
- ↑ Tolerance for activities & handling


Clinical Decision:

- Emphasize standing balance & gait activities
- Continue to address bed mobility, transfers & developmental transitions

Initial Gait Training (Weeks 4-5)

Interventions	Rationale
Stretching; splint wearing schedule <i>Botox injections to B gastroc-soleus, L hamstrings, L elbow flexors & pronators</i>	Diminish tone; maintain ROM
Static & dynamic play with emphasis on sit <> stand & standing Prone stander x 15-30 min/day	Strengthen trunk to improve balance & stability Endurance & standing tolerance

Initial Gait Training (Weeks 4-5)

Interventions	Rationale
<p data-bbox="220 495 672 966">Partial body wt. supported gait training on treadmill & over ground</p> 	<p data-bbox="1186 495 1890 836">Provide trunk support Rhythmic, patterned mvmt to achieve reciprocal stepping</p>
<p data-bbox="220 1096 966 1250">Use of pt's favorite toys, games, songs, etc.</p>	<p data-bbox="1186 1096 1890 1331">Positive reinforcement to increase participation in PT</p>

Initial Gait Training (Weeks 4-5)

Pt. Response:

- ↓ Progress with functional mobility & gait
- ↓ Initiation of stepping & weight acceptance
- ↓ Participation in PT: prefers to swing in harness
- ↓ Motivation to walk with avoidance behaviors

Clinical Decision:

- Modify initial PT goals
- Discontinue PBWSTT
- Initiate aquatic therapy program
- Continue to address functional mobility on land

Modified Plan of Care

Mobility	Initial Goal	Modified Goal
Bed mobility & Transfers	Independent	Supervision
Gait	Independent x short community distances with AD	Mod A x household distances with AD
Stair Climbing	Supervised with HR	Mod A with HR

Aquatic Therapy (Weeks 6-8)

- 20-30 min/day x 8 Rxs
 - 3 sessions with PT
 - 5 sessions with aides
- Initially, pt. placed in small hydrotherapy tank to determine water tolerance
- All subsequent sessions took place in walking tank with adjustable platform with parallel bars



Aquatic Therapy (Weeks 6-8)

- Level of immersion:
 - Xiphoid process
- Water temp:
 - 98 degrees
- Safety:
 - Float at pt's waist
- Activity:
 - Walk laps while retrieving toys & playing games with PT/aide/family
 - Manual assist at trunk to maintain upright posture
- Progression:
 - Instructed to hold parallel bars with R UE to maintain balance & posture
 - Less manual assist



Aquatic Therapy (Weeks 6-8)

- Rationale:
 - Offer motivating environment for movement exploration
 - Promote movement initiation & reciprocal gait
 - Provide postural stability and trunk support
 - Strengthen trunk and extremities
 - Improve aerobic fitness
 - Allow for intensity of therapy necessary for neurological recovery

Aquatic Therapy (Weeks 6-8)

Interventions	Rationale
Land-based gait training	Carryover of gains in water; Intense repetition for motor learning, strength, endurance
Stretching; B AFOs <i>Botox injections to L quads</i>	Diminish tone; Maintain ROM
Static & dynamic play Standing Box x 20-30 min/day	Strengthen trunk; Improve balance & stability

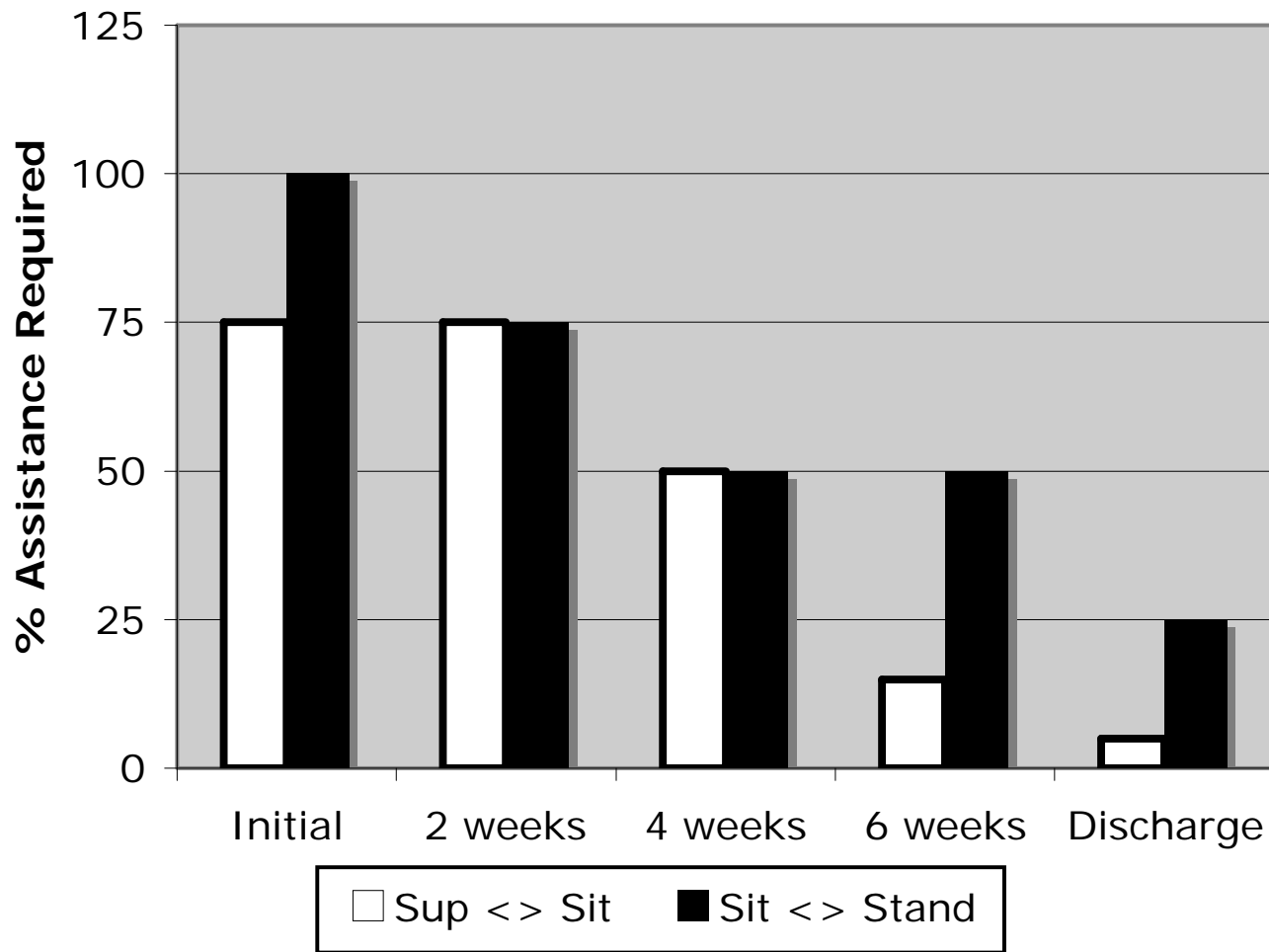
Outcomes Balance

Activity	Initial	4 weeks	Discharge
Ring Sit	Max A	Min-mod A	SBA-CGA
Short Sit	Max A	CGA	SBA
Standing at Bench	Max A	Min A	CGA



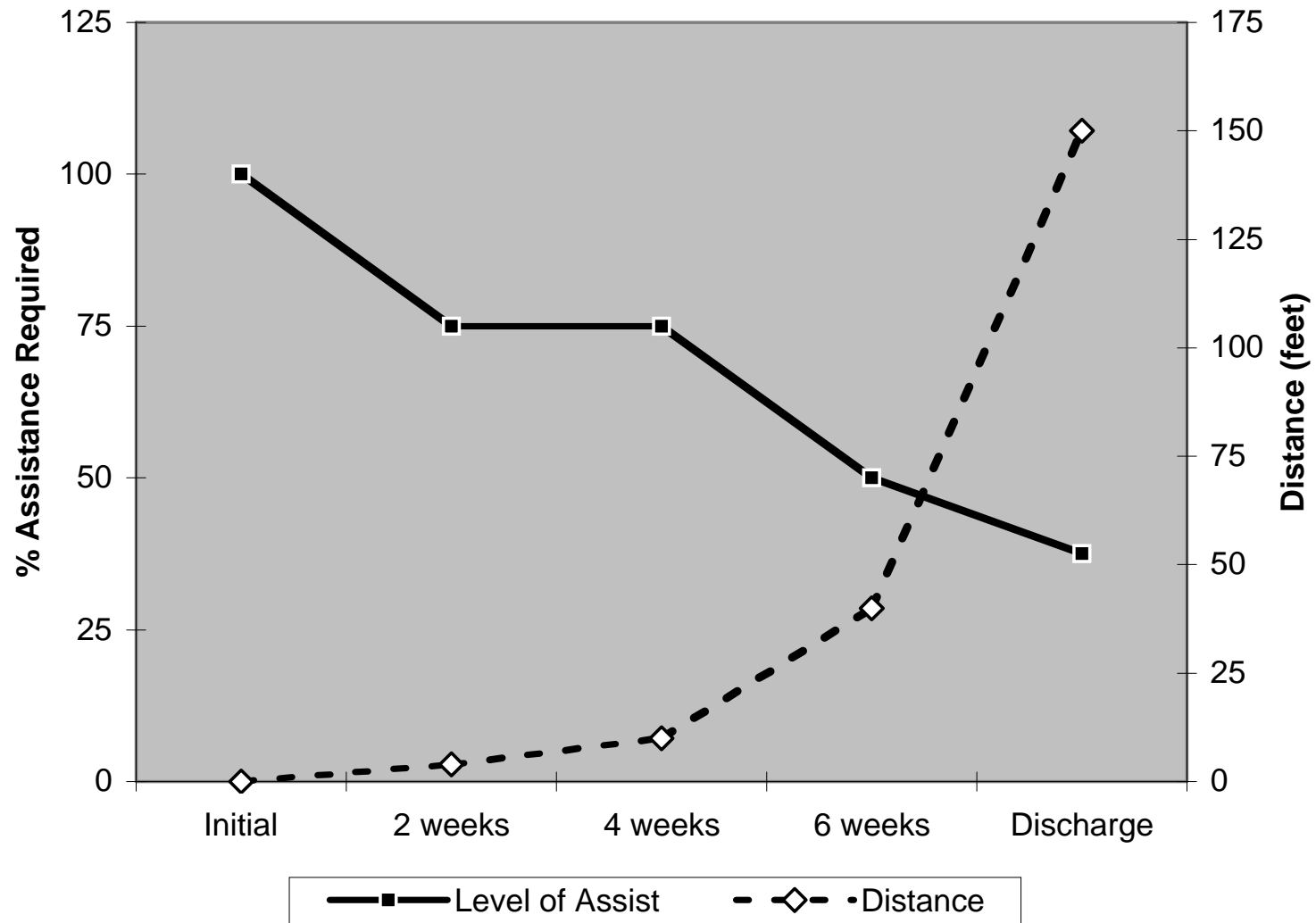
Outcomes

Level of Assistance with Transfers



Outcomes

Progression of Gait Over Time



Outcomes

Observational Analysis

Time	Right LE	Left LE
Initial	Moves against gravity; ↓ WB w/standing	No active mvmt; Hypertonic
4 wks	Favors locked knee; Consistently steps; ↑ ADD (scissors)	Extensor synergy; Flexor withdrawal w/ tactile stim
Discharge	Able to unlock knee & shift wt. laterally and forward	Consistently steps with intermittent tactile cues

Outcomes

Psychosocial Parameters & Cognition

Time	Attention	Behaviors
Initial	10 min Max VCs	Labile; Frequent crying Irritable to handling
4 wks	20-30 Max VCs	Easily agitated; Frustrated w/challenges Asks for mom; c/o stomach pain
Discharge	20-30 min Mod VCs	↑ Participation in therapy with promise of reward

Outcomes

Psychosocial Parameters & Cognition

Time	Cognition
Initial	1-step commands; Responds yes/no; No new learning
4 wks	Emerging 2-step commands; Max A for learning Occasional carryover
Discharge	Emerging goal directed behavior; Max A for learning Some carryover

Discussion

- The pt. participated in intensive aquatic and land-based PT interventions
- He achieved gains in functional mobility, gait distance & active movement
- The pool program motivated pt. to walk, allowed for greater ease of movement & relaxed hypertonic muscles
- AT is useful during acute rehab to promote early functional mobility for pt. with severe motor impairments

Discussion

- Based on physiological properties of water, a fluid environment provides:
 - Postural support and mobility
 - Exploration of movement not possible on land due to gravity & fear of falling
 - Gentle resistance to movement to improve strength & endurance



Discussion

- During AT period, pt. demonstrated:
 - **↑ postural stability**
 - **↓ assistance for sitting, standing, tx & gait**
 - **Ability to step with L LE for first time in pool**
- Researchers examining the use of AT with children with CP describe:
 - Gains in postural control & balance due to buoyancy and decreased gravity
 - Spontaneous active movement of hemiparetic extremity ^{17,39}

Discussion

- Carryover from aquatic environment to land
 - **Pt. achieved ability to advance L LE and accept weight in pool ⇒ consistently demonstrated on land**
- Gains in pool correlated with functional improvements on land^{15,39}
 - Ability to walk further independently
 - Progression from w/c to walking with ADs as primary means of mobility
 - Increased use of paretic UE & improved bilateral hand coordination

Discussion

- Gains in endurance & aerobic fitness
 - **Gait distance: 40 ft \Rightarrow 150 ft.**
- AT linked to cardio-respiratory fitness^{15,16,26}
 - Hydrostatic pressure encourages deep breathing \Rightarrow increased VC & endurance
 - Combination of AT & land-based exercise more effective
- Cardiovascular fitness linked with greater neurological recovery & functional mobility gains among pts. with disabilities^{15,40}

Discussion

- Pt. exhibited:

↓ **Avoidance behaviors**

↑ **Attention span**

↑ **Goal-directed behavior**



- AT shown to improve psychosocial, cognitive and leisure skills following brain injury ^{15,16,41-43}
 - Associated with improved performance in other areas of rehab
- Infants with neurological deficits demonstrate improved behavioral state regulation after AT²⁷

Recommendations

- PTs should consider AT as a means of achieving **early mobility** for pediatric pts. with severe TBI
- Pts. who exhibit **cognitive & behavioral impairments** impacting progress with PT may achieve greater success with AT
- A **combination of AT and land-based gait training** offers a solution for pts. who may not tolerate the intensity of over ground practice required for neurological recovery and aerobic fitness



Limitations

- AT limited to gait:
 - Additional aquatic exercises
 - More direct PT facilitation in pool
- Duration of AT intervention
 - Initiated earlier in rehab program
 - Extended beyond 2-week interval
- Standardized tests or outcome measures
 - HR measurement for EEI calculations

Suggestions for Future Work

- PTs should become familiar with properties of hydrostatics & hydrodynamics, in order to identify appropriate AT interventions for pts.
- Research on pediatric TBI population should emphasize use of AT in acute rehabilitation phase for functional training
- Pediatric PTs are encouraged to seek aquatic solutions for their pts. with severe neurological impairments and clearly document observed changes

Conclusions

- The pool offers a fun & safe environment
- Aquatic interventions may:
 - Encourage active movement and strengthening of paretic extremities & trunk
 - Improve balance, transfers & gait
 - Increase level of participation in PT
- Aquatic therapy as an adjunct to conventional PT may lead to more favorable outcomes than land-based therapy alone

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