ADDRESSING GAIT AND BALANCE IMPAIRMENTS IN THE POOL

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Disclosure
Presenter is the chairperson of the Certificate in Aquatic Physical Therapy Clinical Competence (CAPTCC) program and receives an honorarium as an instructor for the program. Some material for this presentation is taken from the CAPTCC program with permission from the Aquatic PT Section.
Session Learning Objectives

Apply evidence based practice to support the need for aquatic physical therapy intervention to address gait and balance impairments in the adult orthopedic and neurologic populations.

Analyze gait and balance on land then design aquatic intervention to address common gait and balance impairments in the adult orthopedic and neurologic populations.

Session Learning Objectives

Creatively use a variety of equipment for gait and balance activities in the pool.

Evaluate the effectiveness of the aquatic intervention on addressing gait and balance impairments including use of outcome studies.
“We are more alike, my friends, than we are unalike.”

- Maya Angelou

Impairment vs Diagnoses
Impairment Driven =
Multiple Patient Populations covered

Wealth of knowledge
Gait gives clues about multiple body systems

**Cardiovascular system**

**Pulmonary system**

**Musculoskeletal system**
- Strength
- ROM

**Neurological system**
- Hyper/hypo tonicity
- Pain
- Coordination
- Balance
- Cognitive processing
Gait speed: The 6th vital sign
AKA: the functional vital sign
(Fritz 2009, Middleton 2015 – older adults)

- “…almost the perfect measure”
  - Reliable
  - Valid
  - Sensitive
  - Specific
  - Correlates with
    - Functional ability
    - Balance confidence

Gait speed as a predictor of function
(Middleton, Fritz, Lusardi 2015 – Older adults)

Chart used with permission from Stacy Fritz, PhD, PT
Ways to measure gait speed

**5 - 10 meter walk test** – quick and easy – good for those with slow walking speeds.

**Timed Up and Go (TUG)** – quick and easy – more functional with rise/lower into chair and turning as well as walking.

**6 minute walk test** – when longer test is needed to view dysfunction (greater than 1.0 m/s gait speed does well in this category)

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What is normal?

What is the Minimal Clinically Important Difference?

Rehabmeasures.org
Gait in Water vs land

- Lower self selected speeds and vertical ground forces in water (Heywood 2016)

- Inter-joint coordination of hip, knee and ankle was changed when walking in water (Miyoshi 2003 – healthy, Barela 2006- healthy, Cadenas-Sanchez 2015 - healthy)

- Reduced BP during water walking (Lambert 2014 – sedentary adults)

Assess gait outcome on land
Treat gait dysfunction in the pool
Research to support improved land gait with aquatic interventions

- Improved gait speed

- Improved TUG

- Improved gait stability
  (Lim 2013 – older adults)
Outcome measures for Balance

- **Functional reach** – quick and easy for stationary balance
- **Four step square test** – quick and easy for dynamic balance.
- **BERG** – more detailed balance test – takes a little more time than functional reach.

Outcome measures for Balance

- **Tinetti** – great combination of balance and gait but takes a little more time.
- **Self reporting test**
  - Falls Efficacy Scale
  - Activity Specific Balance Confidence Scale (ABC)
Balance in Water vs. Land

- Postural sway in pool vs. land → increased postural sway, lower frequency of sway, more forward posture assumed with eyes closed, upper trunk used to compensate for mediolateral instability. (Marinho-Buzelli AR 2017 – healthy)

Assess balance outcome on land
Treat balance dysfunction in the pool

Research to support improved land balance with aquatic interventions


Research to support improved land balance with aquatic interventions


- Specific type of water exercise: deep water running – (Kaneda 2008- elderly) aquatic walking and jogging (Lee 2015- spinal stenosis) → improved balance

Properties of water that effect gait and balance

- **Buoyancy** → reduces impact of gravity; allows for greater ease of movement with weak muscles, eases pain due to weight bearing issues.

- **Warmth** → enhances parasympathetic systems – reduce tone, reduce anxiety/fear, reduce pain

- **Viscosity** → slows movement/‘falling’ to accommodate slower reaction time.
Gait and Balance in Water

- Greater movement before hitting limit of stability
- Greater time for balance reactions to occur
- Less fear of falling

Facilitates movement past limit of stability to train balance reactions.

Learning Check

What is the best way to assess and document progress toward improved gait and balance function when patient is participating in aquatic physical therapy?

A. Land gait outcome measure
B. Aquatic gait outcome measure
Formally **assess** gait and balance outcome on land

**Treat** gait and balance dysfunction in the pool
STRONG indicators for aquatic therapy to address gait and standing balance impairments

- Dependent on assistive devise
- Unable to single leg stand
- Strength less than 3/5 (commonly core, gluteals and gastrosoleus)

WHY?

People dependent on assistive devise or unable to balance on one leg → Can balance and walk without or with less use of their arms to promote more central strategies.

People with less than 3/5 strength → Can move through full ROM in a functional position which may be impossible on land.
Learning Check

If your patient has low back pain they are a good candidate for aquatic therapy.

A. True
B. False
C. Maybe

Forest and the Trees

Trees:
Physical characteristics 🌳 (ROM, strength, coordination)
and components of gait 🌳 (Stance and weight shifting control)

Forest:
Functional activity 🌳 (gait)
Can’t have a forest without the trees
(need to have components gait)

Sometimes can’t see the forest for the trees
(don’t get lost in treating every physical limitation if it
doesn’t impact the functional goal)
ROM needed for normal gait

- Hip Flexion 30 degrees at heel strike/initial contact
- **Hip Extension 10 degrees at terminal stance**
- **Knee Extension 0 degrees at heel strike/initial contact**
- Knee Flexion 60 degrees during swing
- Ankle Plantarflexion 20 degrees at push off/preswing
- **Ankle Dorsiflexion 10 degrees at terminal stance**

*(Bowker 2002 – Atlas of Limb Prosthetics)*

Addressing ROM limitations in pool

- **Dynamic stretching** – moving body gradually increasing reach and/or speed (Ai Chi)
- **Active stretching** – assume position and actively hold (PNF- contract-relax, hold – relax, contract-relax-antagonist-contract, Bad Ragaz Ring Method, Aqua Yoga, Aqua Stretch)
- **Central Inhibition** – Movements for parasympathetic response often involving slow rhythmical movements and breath control (Watsu, Ai Chi)
Importance of Core Strength in Gait and Balance

- Core Instability Strength training improved core strength, **stride velocity, functional reach** and **TUG**. (Granacher 2013 – older adults)

- Systematic Review (20 studies) - found correlation between trunk muscle strength/trunk muscle composition and **balance, functional performance (including gait) and falls**. (Granacher 2013 – systematic review older adults)

Importance of Core Strength in Gait and Balance

- Change in pain and abdominal muscular endurance were **significant predictors of change in disability** after aquatic therapy (Baena-Beato 2014 – Chronic low back pain)

- Significant **improvement found with disability**, pain, abdominal strength, handgrip after aquatic exercise program (Baena-Beato 2014 – Chronic low back pain)

- Core stabilization exercise trainings on land or in water have similar **benefits in functional status** of patients with LBP. (Bayraktar 2013 – low back pain)
Addressing core strength in pool

• Kind of device is not relevant if exercise performed at maximal velocity (devises - lg/sm, drag/float)

• Latissimus dorsi maximal activation is better in xiphoid depth vs clavicle depth (rectus abdominus and lumbar erector spinae same at both depths)

(Colado 2013 – male students)

Addressing core strength in pool

• Kind of devise not relevant if exercise performed at maximal velocity (devises - lg/sm, drag/float)

• External oblique activation greater on contralateral side

(Borreani 2014 – male students)

SPEED IS KEY FOR STRENGTHENING IN POOL
Importance of Gluteals in Gait

- **Glut med** greatest intermuscular adipose tissue → higher gait variability (Addison 2015 – Older adults)

- **Glut max** and **glut med** weakness → higher incidents of falls (Inacio 2013- older adults)

- Higher **glut med** activation noted with stepping tasks (Dwyer 2013- hip OA)

- Early Stance muscles → Vasti, adductor magnus, **glut med** (Neptune 2016 – young healthy adults)

Gluteal Training in Pool

- Aquatic exercise → Improved strength glut med with aquatic exercise

  (Rahmann 2009- THA, TKA)
Importance of calf musculature for gait and balance

- Late Stance muscles → glut med, soleus, gastrocnemius (Neptune 2016)
- Flexor hallucis longus strength contributes to push off in gait (Peter 2015)
- Triceps surae (med/lat gastroc and soleus) work dependently (Akasaka 2004)
- Adipose tissue in calf of elderly → poor balance and mobility. (Scott 2015-older adults)
- Plyometric training → plantar flexion strengthening (Markovic 2010)

Calf training in Pool

- Aquatic exercise → Improved strength plantarflexors with aquatic exercise + improved TUG
  (Katsura 2010-older adults)
- Underwater treadmill walking → less intense gastroc work
  (Shono 2007-older adult women)
Aquatic Plyometric training

Peak impact forces $\rightarrow$ reduced aquatic vs. land (Donoghue 2011 - healthy males)

Power in propulsion during exercise $\rightarrow$ greater mechanical peak power
- aquatic better than land (Louder 2016 – healthy males)
- aquatic and land similar (Heywood 2016 – systematic review)

Aquatic Plyometric training

Creatine Kinase production (indicating muscle damage) $\rightarrow$
Greater in land vs aquatic (Jurado-Lavanant 2015 – healthy males)

Aquatic vs. land plyometric training resulting in improved land vertical jump performance (Stemm 2007 - healthy males $\rightarrow$
aquatic and land same results; Jurado-Lavanant 2015 – healthy males $\rightarrow$ land better)
Learning Check

To increase intensity for strengthening in the pool you should …

A. Have many different equipment options available to use as patient progresses
B. Increase speed of movement
You know it’s all about that Bass
(I mean ...Stance)

Take advantage of the pool. People can practice stance skills (especially single leg stance) without UE support much easier in the pool forcing them to build CENTRAL strength and motor planning strategies during stance control.

Importance of Shifting Control

Anterior-Posterior shifting

Lateral Shifting

Double leg and **SINGLE LEG** Shifting
How to improve gait and balance with aquatic therapy

Theory

Practice

Missing Component

Find missing component that effects gait/balance. Work on the missing component in the pool. Check for progress on missing component when in pool. Re-assess land gait outcome measures at selected intervals.

- Strength (big culprits – core, gluts and GS)
- Pain (antalgic response)
- Endurance (cardiovascular exercise)
- Flexibility (big culprits - spine, hip flexors, knee, ankle)
- Balance (fall risk)
- Motor planning (coordination, speed modulation, rhythm)
Easy as 1-2-3

1. Select missing component that impedes function.
2. Work on the missing component.
3. Check for progress.

Learning Check

Select the best way to treat gait dysfunction in pool.

A. Address missing components of gait.
B. Water walking with increased repetition.
Learning Check

How can you tell if your aquatic treatment is improving patient’s gait and balance.

A. Address missing components of gait and balance in the pool and ask patient if gait and balance are improved at home.

B. Check for progress of selected missing components when in pool. At progress report assess gait and balance goal with land outcome measures.

Other things to consider....
Homemade equipment

Get Creative!

Rhythm and Timing is essential

Rhythmic auditory cueing → improve stride length, cadence and gait speed (Yu 2015)

Music salience → effects gait cadence and stride length (de Bruin 2015)

Rhythmic sound training → activates area of brain involved with motor planning and sequencing (Bengtsson 2009, Ivry 2004)
Music Cadence in Pool

- Increase in Musical Cadence → increase in physiologic response with aquatic exercise

  (Bartolomeu 2016 – younger vs older women
  Barbosa 2010 – healthy women)

Feedback

Positive feedback → increased retention of the motor memory (Galea 2015 - healthy)

Nocebo effect can cause unintended harm → (Dieppe 2016,
Greville-Harris 2015)

KEEP IT POSITIVE
Power of the Nocebo

(Dieppe 2016, Greville-Harris 2015)

Your alignment is all messed up. No wonder you're in so much pain.

Look how well you can balance on one leg now.

Emphasis the positive

I CAN'T
Allow movement exploration
Guide for success but allow mistakes
Praise accomplishments

Dosage
Low difficulty → negative learning incentive
Moderate and demanding task → positive learning incentive (Bauer 2016 - healthy)

MAKE IT HARD

Motor-cognitive dual tasks → improves gait velocity, stride length, balance and cognition (Fritz 2015 – Neurological Disorders)

CHALLENGE WITH DUAL TASK
Dosage

**High intensity** progressive resistance strength training → Safe for older adults (Raymond 2013 - geriatric chronic health conditions)

**High intensity** and high dosage exercise → better than moderate to low intensity exercise to improve gait speed. (Lopopolo 2006 - community dwelling elderly)

HIGH INTENSITY

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Dosage

**High repetitive** task-oriented and task-specific training → improved function (Veerbeek 2014 – Post Stroke)

**Repetition**-based balance training program is better than an error-based balance training (Cug 2106 – healthy)

REPEAT, REPEAT, REPEAT
Learning Check

What is best strategy for adjusting intensity during aquatic treatment interventions?

A. Progress aquatic therapeutic exercise within a comfortable range.
B. Progress aquatic therapeutic exercise to provide a constant challenge.

Most bang for your buck...

Avoid use of UE for to support balance and gait in pool to build central strategies for movement

Single leg standing pelvic control for glut/core strengthening and balance training

Jumping activities for PF strengthening

Check and address ROM limitations that might limit normal gait

Shifting control is essential
Most bang for your buck...

General conditioning for cardiovascular endurance

Utilize metronome/music for central processing improvement

Find right dosage for proper training effect – challenge your patients!
  – MAKE IT HARD

Avoid Nocebo effect – keep it positive - Allow movement exploration and praise success

Specific Gait training – Aquatic Intervention Ideas
<table>
<thead>
<tr>
<th>Land Problem</th>
<th>Missing Component</th>
<th>Aquatic Intervention Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor ant weight shifting with sit to stand transfer or Retropulsing gait</td>
<td>Improve anterior weight shifting for sit to stand transfers Improve forward movement with gait.</td>
<td>Halliwick transversal rotation Water Specific Therapy activities... Standing weight shifting forward and backwards without use of arms if possible. Give target for abdomen with forward shift Pre-gait Stepping forward and backwards without use of arms if possible. Start with small step and progress to larger step as tolerated. Standing or squatting to prone floating or supine to prone float Suspended sitting – balance reactions into forward flexion with ball pass Ball pass under leg while walking forward Ball push with trunk while standing or walking forward Step up onto low step and reach forward to target Don’t allow use of UE sculling action in water</td>
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<tr>
<td>Sit to stand Transfer Uneven weight bearing or Knee hyperextension with stance</td>
<td>Improve weight bearing on affected side. Improve control of involved leg to reduce knee hyperextension</td>
<td>Halliwick Sagittal rotation WST activities ... Pre-gait standing weight shifting side to side and manual cues to control hyperextension and without use of UE if possible. Pre-gait stepping sideways with uninvolved leg without use of arms if possible. Start with small step and progress to larger step as tolerated. Uninvolved leg lift (stance on involved side with verbal or manual cues to prevent hyperextension) Squatting with even weight bearing or single leg squat on involved side if possible. High kneeling on kickboard or step Ball pass under strong leg with side step away from involved side (encouraging weight bearing onto involved side) Ring pick up with strong leg (encouraging weight bearing onto involved side)</td>
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<tr>
<td>Leaning forward at hips</td>
<td>Improve upright posture</td>
<td>Weight shifting forward against turbulence and cues for spinal extension</td>
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<td>Walking forward with theraband resistance at pelvis (PT behind holding onto theraband)</td>
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<td>Standing leg extensions (AROM for hip flexors) – manual cues for alignment</td>
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<td>Stretches for spinal extension, hip flexors, pecs and HC</td>
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<td>Strengthen gluts with standing ex’s – Single leg if possible.</td>
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<td>Don’t allow sculling of UE if at all possible with activities</td>
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<td>Hold Kickboard in front with walking so patient can’t look down at feet. Cue to look forward not down.</td>
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<td>Volleyball while standing or moving</td>
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<td>Noodle raise over head – standing or moving</td>
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<td>Shuffling or Short step length or Poor push off or Excessive lateral wt shifting or Poor heel strike or Rigid spine</td>
<td>Improve step length and speed</td>
<td>Pre-gait – Stepping with focus on push off of stance leg and increasing step length –</td>
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<tr>
<td></td>
<td>Improve Heel strike</td>
<td>Increase step length with markers on floor</td>
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<td></td>
<td>Improve Push off</td>
<td>PVC pipes for reciprocal arm swings</td>
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<td></td>
<td></td>
<td>Walk forward with kayak paddle</td>
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<td></td>
<td></td>
<td>Decrease number of steps to get across pool.</td>
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<td>Metronome work with increasing cadence while using markers to keep step length.</td>
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<td>Ai Chi or Dancing to music</td>
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<td>Stepping over cones – around obstacles</td>
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<td></td>
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<td>Lunges with reciprocal arm touch</td>
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<td>Walk with fins</td>
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<td>Heel raises - Toe walking</td>
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<td>Hopping</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td>Unable to heel strike or maintain balance due to buoyancy</td>
<td>Appropriate body control in water.</td>
<td>Go to shallower water if possible</td>
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<td>Weight belt around waist or ankles</td>
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<tr>
<td>Unable to heel plant due to tight heel cords, poor proprioception, poor LE control or spasticity</td>
<td>Improve foot alignment in standing</td>
<td>Add weights or straps to ankle and use for manual assistance by therapist. (Therapist toes can hook onto weight/strap)</td>
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<td>GS stretches and/or tonal reduction prior to standing</td>
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<tr>
<td>Ataxia</td>
<td>Reduce ataxia</td>
<td>Add weights to waist if general ataxia – add to ankle if only in LE.</td>
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<td>Poor swing control due to weakness or poor proprioception</td>
<td>Improve LE swing control</td>
<td>Add weight to ankle with activities with enough weight to anchor legs during stance (but not so much to prevent ease with swing phase of gait)</td>
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<td>Ataxia</td>
<td>Reduce ataxia</td>
<td>Add weights to waist if general ataxia – add to ankle if only in LE.</td>
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<tr>
<td>Foot drop/slap</td>
<td>Protect foot/ankle/knee and strengthen DF to reduce foot drop.</td>
<td>Ace wrap foot for ankle DF assist – if very weak or absent DF.</td>
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<td>Weight shifting backwards enough to activate dorsiflexors.</td>
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<td>Ring pick up</td>
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<td>GS stretches</td>
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<tr>
<td>Trendelenburg</td>
<td>Improve pelvic control with single leg stance.</td>
<td>Pre-gait – f/b, s/s, marching, leg swings</td>
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<td>Glut med strengthening</td>
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<td>Single leg activities</td>
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Summary

Improved Balance and Gait
Easy as 1 2 3

Thanks
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