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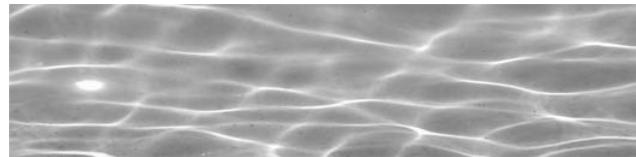
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## Introduction to Aquatic Therapy Back to Basics

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## Learning Outcomes

After this course, participants will be able to:

- Provide at least three medical justification statements for the use of aquatic therapy relating specific therapeutic benefits of buoyancy, drag forces and hydrostatic pressure in a patient's plan of care.
- Identify at least five precautions and contraindications to aquatic therapy.
- Recognize at least three primary differences of human movement and muscle activation in the water compared to land.
- Identify at least three progressive rehabilitation exercises based on the properties of buoyancy and drag force.
- List the use, benefits, and precautions to the three main types of aquatic therapy equipment (buoyancy, drag, and floatation).

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## Hydrodynamics....



continued

## Buoyancy (Video)

Upward thrust that changes biomechanical stress!

Archimedes' principle states that when a body is wholly or partially immersed in a fluid at rest, the body experiences an upward thrust equal to the weight of the fluid displaced.



continued

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## Three-Fold Power of Buoyancy

**Supports****Resists****continued**

## Body Type



How does body type affect buoyancy and a person's ability to float?

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## Relative Density = mass of an object

mass of equal volume of water

- Float

- RD < 1
- Higher body fat %
- Inhale
- Flaccid



- Sink

- RD > 1
- Lean muscle mass
- Exhale
- spasticity



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## Depth & Weight Bearing

Water level	% WB
ASIS	56%
Xiphoid	30%
C7	10%
Over head	0%

*Harrison and Bulstrode 1987*

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## % WB with fast walking

Depth of immersion	% WB
C7	25%
Xiphosternum	50%
ASIS	75%

But what happens  
with fast walking  
and running?

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But how does it unweight the cervical spine when your head is out of the water?



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## Buoyancy Supports Upper Extremities

- With support of the buoyancy the gravitational pull on the upper extremities is reduced.
- Leading to reduction of traction on the upper trapezius and levator scapular muscles
- In turn reducing the compression forces at the cervical facet joints allowing for mobility and reduced pain.

continued

## Buoyancy Works



Water provides an environment to perform a progressive program from passive to resistive.

The type of exercise is dependent upon movement, limb position and equipment use.

continued

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## VMO Activation (Fuller et al. 1999)

- VMO activation was 50% waist deep and 25% chest deep compared to land
- Follows what we know about buoyancy support



continued

## Shallow vs. Deep water running



Study by Dowzer, Reilly and Cable (1998) found significantly greater loss of stature in participants who performed treadmill and shallow water running compared to deep water running.

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## Therapeutic Benefits of Buoyancy

- Decreased weight bearing/ decreased joint compression forces leading to decreased pain.
  - Allows for increased ROM
  - Allows for gait training without antalgic compensations
- Decreased effects of gravity
  - Ease of movement
  - Safe for balance, reduce fear of falling
  - Counters effects of gravity on venous pooling in dependent limbs
- Increases ease of handling
- Provides safe environment to perform passive, active assistive and resistive ex.
- Supports and assists weak muscles



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What types of patients would benefit from the buoyancy?

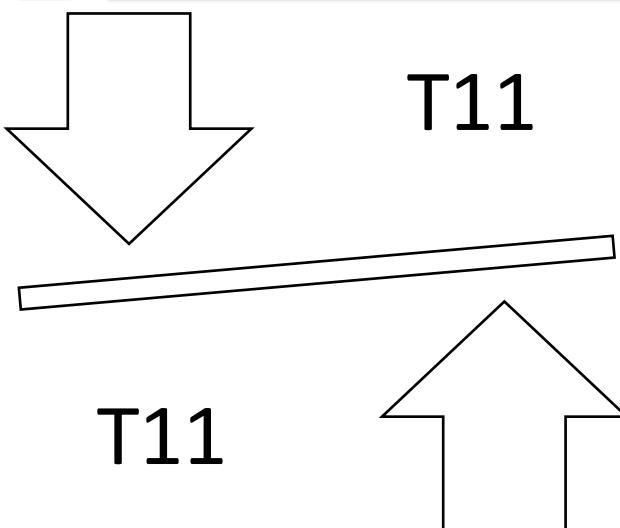
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## Considerations and Challenges Related to Buoyancy

- Therapist may have difficulty remaining in a fixed position.
- May be difficult to stabilize the patient
- The patient may experience less proprioceptive input.
- Flaccid extremities may float

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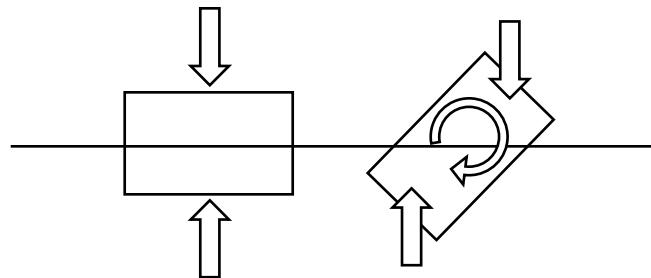
Immersion point in which the body is now influenced to a greater degree by buoyancy compared to gravity.

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## Rotational Forces

COG= pelvis  
COB= mid-chest



**Bougier's Theorem and Metacentric Effect**

continued®

## Drag Forces ag Forces



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Cohesion,  
Adhesion,  
Surface Tension

continued

Viscosity= Thickness Frictional Resistance

continued®

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$$FD = PCV^2A/2G$$

- FD= drag force
- P= fluid density
- C= coefficient of drag (related to how streamlined an object is)
- V= Velocity of object (m/sec)
- A= frontal area of the object (combined frontal area of the limb and hydro- fitness device)
- G= gravitational constant (1.0 kg m/N sec)

continued

## Clinical question...

Based on the drag force equation  $FD = PCV^2A/2G$ ...

If you double your speed what happens to the resistance?

It increases exponentially to four times the resistance.

If you double your surface/ frontal area what happens to the resistance?

It increases linearly to double the resistance.

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## Shoulder Muscle Activation Aquatic and Dry Land Comparison (Kelly et al. 2000)

- RCT N=6 healthy males 21-27 y.o.
- Muscle activation of supraspinatus, infraspinatus, subscapularis, anterior, posterior and middle deltoid. During shoulder elevation (in scaption)
- 30°/ sec and 45°/ sec test speeds were significantly less when performed in the water vs. on land.
- At 90°/sec movement in water caused greater activation of muscles.

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## Example: Hydro-tone bell

- Hydro-tone bell orientation and velocity of movement have considerable effect on force production.
- 50% more force produced with bell is positioned at 45° angle compared to 0° when velocity was 152 cm/sec
- With slow velocity 31cm/sec was close to equal in both positions.

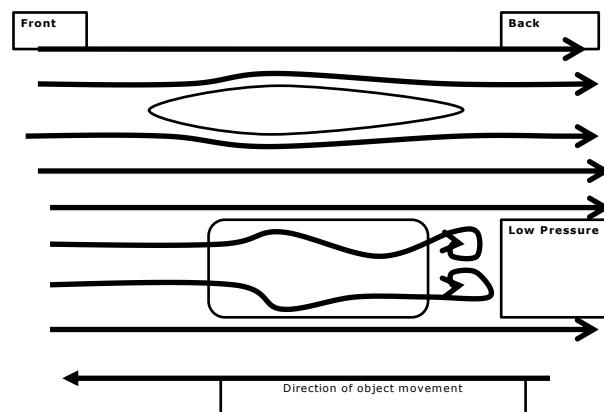


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## Streamline/ Laminar Flow VS Turbulent Flow

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Which is harder walking forward in the water or side-stepping?

Why?

continued

Bernoulli Effect: states that the pressure in a fluid decreases as the speed increases. Internal fluid is inversely proportional to the stream velocity.

Eddies are low-pressure areas creating suction that can be used to pull a body through the water.



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How can you use eddies to assist a patient?



continued

## Benefits of Viscosity

- Strengthening muscles in both directions during an exercise resulting in balance of strength (movement necessary for drag force resistance)
- Resistance can be controlled by speed and surface area, therefore progressive in nature.
- Decreased movement = decreased resistance= decreased load.
- Slows movement allowing for improved quality, smoothing out jerky motions
- Provides increase time response for patients' equilibrium reactions.

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## Benefits of Turbulence and Flow

- Method of increasing resistance to movement to increase strength and endurance.
- Training, “speed moves” up to approximately 90 degrees per second
- Utilizing eddies to assist movement through the water for ROM and relaxation. (mother Duck and her chicks)
- Turbulence increases proprioceptive feedback and can be used to treat tactile defensiveness, and challenge patients during balance and stabilization exercise.

continued

## Patient types that benefit from drag forces and viscosity....

- Parkinson's disease and Cerebral palsy: dampens involuntary movement
- Anyone with weakness and muscle imbalance
- Sports rehab
- Patients who need postural control and spine strength

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## Challenges of drag forces

- Too much turbulence, often occurring when you have multiple programs in the same pool at the same time.
- Individuals who are significantly weak may have difficulty moving, breaking the surface tension and overcoming drag forces when exiting the pool.
- Tactile defensiveness and vestibular: easy to over stimulate

continued

Concentric and impact forces of single leg jumps in an aquatic environment vs. on land  
Triplett et al. 2009

- Found:

- Softer landings

Stronger take off



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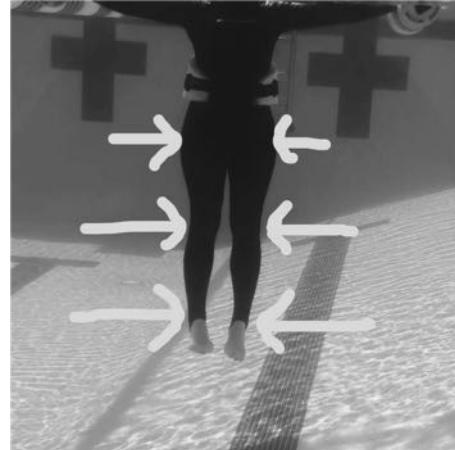
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## Hydrostatic Pressure

- Pascal's Law states fluid pressure is exerted equally on all surface areas of an immersed body at rest at a given depth.
- Pressure increases linearly with depth of water.
- Pressure increases 1mmHg per 1.36 cm (.54 inches) of water (or 22.4 mmHg per foot depth)
- Force produced by water against a submerged body

**continued**

## Benefits of Hydrostatic Pressure

- Aids in the resolution of edema leading to increased ROM
- Helps build up muscles of inspiration
- Increased venous return and circulation
- Increased O<sub>2</sub> uptake
- In part responsible for reducing heart rate while in water.
- No movement necessary

continued

## Who benefits from hydrostatic pressure?

- COPD
- Diabetes
- Developmental delay
- Pregnancy (venous pooling in LE)
- Ankle and knee injury/ post-op for edema control
- Lymphedema post mastectomy

continued

## Therapeutic Importance in Controlling Edema

- Research demonstrates reduced quadriceps activity with knee joint distension.
- Threshold for inhibition of VMO about 20-30 ml and for rectus and vastus lateralis 50-60 ml.



continued

## How does HTN decrease the edema reducing effect of hydrostatic pressure?

- The pressure caused by the water must be greater than the diastolic pressure to create a pressure gradient.
- Normal BP = 120/80
- At a depth of 4feet there is 88.88 mmHg of pressure (12inches x 4 feet / .54)

continued

## Lymphatic Drainage

- Standing neck deep in water arm at side there is 50-60mmhg on the hand (far greater than the venous and lymph pressure)
- One study showed slow paced aquatic exercise is more effective than conventional aquatic exercise immediately after the intervention for arm volume. (Deacon, de Noronha, Shanley, Young. Brazilian Journal of Physical Therapy 2018)

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## How important is Temperature?

Transfer of thermal energy!

1st Law of thermodynamics states the total heat and thus energy content of the system remains the same.

Specific heat is defined as the amount of energy to raise the temperature of 1g of water by 1°C. The specific heat of water is 1000x greater than air. Every water molecule adjacent to the skin will absorb or release far greater quantities of heat compared to air molecules of the same temperature.


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Water is an efficient conductor of heat, conducting heat 25 times faster than air.

Recommended temperatures based on activity:

Activity	Temperature range
Vigorous exercise	28-30°C (82-86°F)
Light exercise/ stretching	33-35°C (91-95°F)
Passive relaxation	35°C (95°F)

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**continued***Thermal neutral is 92 °F / 33° C*

## Water Temperature

- Warm Water 84-92
- Neurological
- Chronic pain
- Fibromyalgia
- Arthritis
- Pediatric/ children
- Frail
- Cooler Water 82-88
- Orthopedic dx.
- Athletes
- Multiple sclerosis
- During Pregnancy/ prenatal
- Obese
- Cardiac

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## Therapeutic benefits to water temperature

- Cooler water helps prevent overheating with exercise.

Warmer water allows for muscle relaxation, reduced muscle spasm and pain.

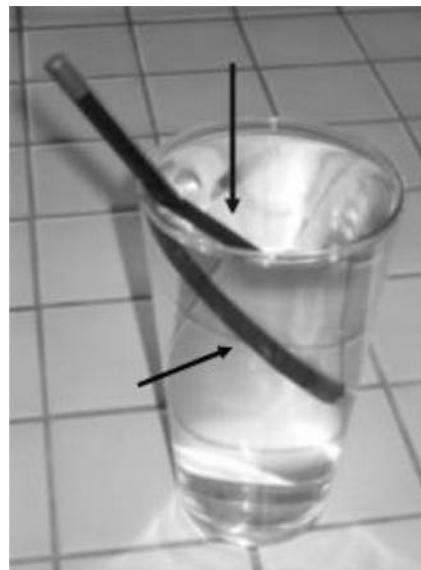
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## Additional considerations

Properties of water you can't change but are a factor in rehabilitation.

continued



Refraction

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**REFRACTION:** Is the bending of a ray of light as it passes from one medium to another medium of a different density

In the pool, refraction causes objects and extremities to appear 25% larger and 25% closer to the surface than they actually are.

As the immersed person is placed farther away from the observer, the angle change is greater and the difference between actual position and “virtual” position increases.

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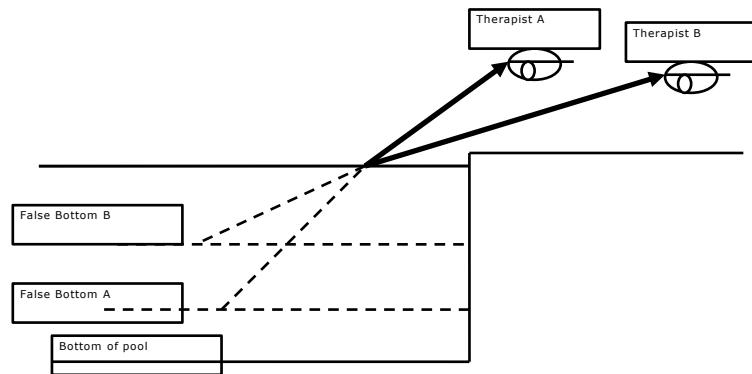
What do you see?



Objects and extremities appear 25% larger and 25% closer to the surface than they are. Limbs like our pencil appear to bend at the water level.

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Reflection

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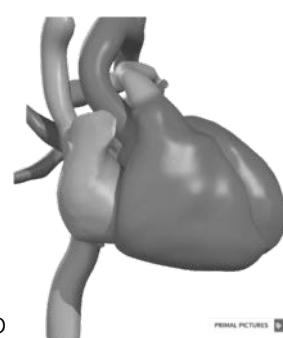
## Additional therapeutic property of water...

- Water = virtual plinth
- Easier access to all sides of the body

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## Physiological Effects of Immersion

- Increase in central blood volume, cardiac volume and stroke volume
- Decreased Heart Rate (cooler water)
- BP generally decreases in warm water (dependent on several factors)
- Total work of breathing increases 60%
- Blood supply to muscles increased
- Improved O<sub>2</sub> delivery to muscles
- Improved removal of lactate and other metabolic end products.
- Mobilization of extracellular fluid leading to increased urine output
- Increased loss of K<sup>+</sup> and Na<sup>+</sup>
- Suppression of thirst
- Sympathetic nervous system partially suppressed



PRIMAL PICTURES

**continued**<sup>®</sup>

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## What does this mean clinically?

- May use Rate of Perceived Exertion vs. HR to determine intensity levels.
- Counsel patients on using restroom prior to getting in the pool
- Encourage patients to drink fluids even if not thirsty especially on hot days or with higher intensity workouts.
- Close supervision and monitoring of vitals for those with cardiac compromise and other medical issues.
- Renal failure and dialysis: may want medical clearance due to shift in central volume.
- Monitor clients with DM for signs of hypoglycemia especially if this is a new exercise routine

continued

## Precautions and Contraindications

- |   |  |
|---|--|
| <ul style="list-style-type: none"><li>▪ Open wounds</li><li>▪ Soft tissue infections</li><li>▪ Skin conditions</li><li>▪ UTI</li><li>▪ Febrile conditions</li><li>▪ Allergies to pool chemicals</li><li>▪ Questionable continence</li></ul> | <ul style="list-style-type: none"><li>▪ Renal failure</li><li>▪ Seizure disorder</li><li>▪ Hydrophobic patient</li><li>▪ Unmanaged cardiac problem</li><li>▪ Excessive HTN</li></ul> |
|---|--|

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## Types of Equipment

- Floatation
- Buoyancy
- Resistance by drag or increased surface area
- Mask and snorkel
- Shoes
- Steps
- Weights, tubing, theraband, sticks, balls

continued



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## Floatation Equipment



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## Deep Water Alignment



continued®

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## Buoyancy Equipment



continued®

## Buoyancy Cuffs

Different sizes

Important to consider  
lever arm

Significantly increases  
challenge to remaining  
vertical

Caution when adding to  
program



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## Additional equipment



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## Drag Force Equipment



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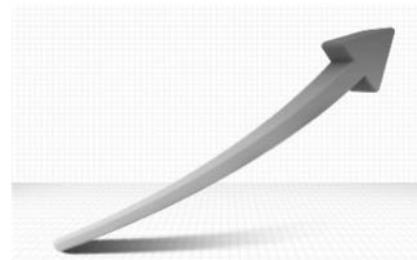
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Sometimes equipment  
has multiple uses...

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## Basic Aquatic Exercise Progressions

- Buoyancy
- Drag forces
  - Increase speed
  - Increase surface area
  - Increase turbulence
- Increase lever arm
- Equipment use
- Use inertia: new movement

**continued**<sup>®</sup>

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## Laws of Physics

- Leverage
- Inertia
- Acceleration
- Action/ reaction

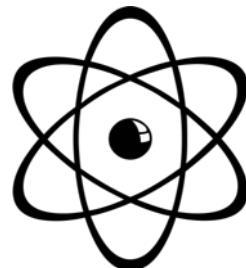


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Stop start



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## Walking/gait training in the water



Functional training  
Progressive weight bearing  
For the hydrophobic patient  
Starting point for the non-swimmer, or those unable to stabilize in deep water.  
Starting point for post-op spinal fusions, and SI joint diagnoses.

continued

## Differences walking in the water.....

- Balance reactions need to be faster and stronger on land
- Proprioceptive feedback from viscosity, hydrostatic pressure and turbulence can provide sensory feedback to a limb that is not on land.
- Decreased weight bearing/ joint compression from the force of buoyancy may reduce proprioceptive input.
- Muscle force is different due to drag forces and buoyancy.

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## Walking in the Water

- Physical properties of the water can benefit the patient for gait training these properties also alter gait patterns normally seen on land.
- Statistical difference between cadence, step length and speed when walking normal and fast on land.
- In the pool cadence during normal and fast walking was different however no significant difference in step length with these speeds.

continued

## Spatio-Temporal Parameters and Interlimb Coordination for Older Adults

- Stride length less in water
- Stride time increased (greater than doubled)
- Walking velocity and cadence decreased
- Participants did not change the proportion of each walking cycle (temporal organization) land vs. water
  - 40% swing, 60%stance with 9.5% double limb support on either side of single limb stance (this is similar to healthy young adults)

▪ Degani, AM, Danna-dos-Santos, A. (2006)

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## Muscle Activation Intensity (%MVC)

- Muscle activity during human locomotion tends to be lower compared to land when walking speeds are self-selected
- When walking at identical speeds vastus medialis, rectus femoris, biceps femoris and gastrocnemius muscle activity was higher compared to land.
- Older adults had greater hip flexor/ extensor activity (approximately 56% higher) and less ankle plantar flexor activity (about 31% lower) compared to younger subjects. (this is congruent with land based locomotion research)
  - Musumoto & Mercer 2008

**continued**

## Muscle Activity During Aquatic and Land Exercises in people with and without LBP

- 40 men- 20 CLBP/ non-specific more than 12 weeks and 20 controls age (33.1-28.5)
- Pool exercise 1.25 m depth at 28°C
- No significant between group differences
- HR higher on land RPE varied
- Muscle activation higher 29% on land and 5% in water remaining no differences
- All muscle activation was sufficient to improve motor control and endurance aspects of trunk muscles to stiffen segmental joint of the spine
- Pain levels low but reported twice as often on land
  - Stelios et al. Physical Therapy vol 99 (3) 2019

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## Exercises Performed

- Trunk rotation
- KB push pull
- Punches (buoyant discs) \* \*\*
- Squats with hand paddles \*\*
- Alt shoulder flex/ ext. with paddles \*
- Plank roll outs
- Hip abd
- Hip extension
- SL squats
- Side-step
- DB hold at side with standing march \*\* \*\*\*
  - \*increased EO \*\* increased RA \*\*\* increased erector spinae for water condition

continued®

## Muscle Activation with Backward Walking

- Backward walking in water resulted in significantly higher muscle activity of the paraspinals (increased 61%), vastus medialis (increase 83%) and tibialis anterior (increase 47%) compared to walking forward in the water.
  - Musumoto & Mercer 2008

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Video examples...

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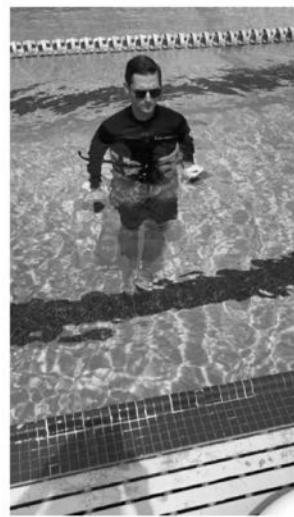


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Thank You! Any questions?



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