Objectives

- List risk factors for developing symptomatic OA
- Describe the therapeutic benefits of buoyancy, drag forces and hydrostatic pressure
- Discuss latest research regarding aquatic therapy for individuals with OA and/or TKA and THA.
- Compare muscle activation during walking in the water and on land.
- Implement aquatic exercises to increase mobility, function and gait.

According to the Arthritis Foundation

www.arthritis.org

OA affects 27 million Americans
After age 50 women are more affected

Cost the U.S. economy nearly 128 billion per year.

The average direct cost of OA is $2600 and total cost about $5700 per year, per person.
Risk Factors Knee OA

(Felson et al. 1997/Blagajtchik et al. 2010/ Murphy et al. 2008/ Klussmann et al 2010)

– Aging*
– Women OR 1.8
– Higher BMI OR 1.6 for every 5 unit increase
– Increased weight OR 1.4 for every 10-lb gain
– Obesity* pooled OR 2.63 (higher OR in some studies)
– Previous trauma OR 3.86
– Daily lifting and carrying of loads OR 2.3 (≥ 1,088 tons/ life)
– Kneeling/squatting Male OR 2.16 females OR 2.52

* Greatest lifetime risk of symptomatic knee OA
OR= odds ratio

Risk factors for Hip OA

(Hip OA Clinical Practice Guidelines, Cibulka 2009)

Age

Hip Developmental Disorders (CHD, Legg-Calve
Perthes, slipped capital femoral epiphysis)

Previous hip injury
**Argument for Weight Management**

- “For every pound you gain, you add 3 pounds of pressure on your knees and six times the pressure on your hips” [www.arthritis.org](http://www.arthritis.org)
- Messier et al. (2005) discovered in overweight older adults for every pound lost there was a 4 pound reduction in pressure exerted on the knees.
- March & Bagga (2004) showed that risk for OA increased by 36% for every 2 units of BMI increases (5kg of weight gain)

**AAOS clinical practice guideline for the treatment of OA of the knee includes:**

- Patient education and lifestyle modification
- Encourage weight loss
- Low impact aerobic fitness exercise
- Quad strengthening and ROM/flexibility exercise
- Pain relievers and steroid injection for short-term pain relief.
- Hyaluronic acid injection evidence is inconclusive usually no more than 6 months relief, does not work on severe OA/ “bone on bone”

**OARSI recommendations for management of hip and knee OA**

- Recommend referral to a physical therapist for appropriate exercise and assistive device PRN
- “Patient’s with hip and knee OA should be encouraged to undertake, and continue to undertake, regular aerobic, muscle strengthening and range of motion exercises.
  For Patient’s with symptomatic hip OA, exercises in the water can be effective”
- 25 recommendations in total. (Zhang et al 2008)
Randomized Controlled Trial of the cost-effectiveness of water-based therapy for lower limb osteoarthritis. (Cochrane et al. 2005)

312 patients over 60 years with hip & or knee OA
– Group 1 = water exercise 1 year period
– Group 2 = usual care with quarterly phone interview.
Concluded: group-based exercise in water over one year can produce significant reduction in pain and improvement in physical function in older adults with lower limb OA. It also found favorable cost-benefit outcome.

Comparison between electro-acupuncture and hydrotherapy, both in combination with patient education and patient education alone, on the symptomatic treatment of OA of the hip. (Stener-Victorin et al 2004)

45 people ages 42-86 with radiographic changes and pain related motion/ pain on load and ache.
– Group 1 = electro-acupuncture
– Group 2 = hydrotherapy
– Group 3 = both with patient education
– Group 4 = patient education only

Groups 1,2 & 3 had long-lasting effect, shown by reduced pain and ache and increased functional activity and QOL.

Hip OA
Clinical Practice Guidelines
Orthopedic Section of the APTA (Cibulka 2009)

• Risk factors
• Examination measures
• Interventions
  – Patient education (moderate evidence)
  – Functional gait and balance training (weak evidence)
  – Manual therapy (moderate evidence)
  – Flexibility, strengthening and endurance exercise (moderate evidence)
**CPG: Examination Measures**

- 6 minute walk test
  - Minimal detectable change (MDC)= 61.34m
- Self paced walk test (walk 40m for time)
  - MDC= 4.04 seconds
- Stair measure (up/ down 9 steps for time)
  - MDC= 5.5 seconds
- TUG
  - Fall risk > 13.55 seconds

**CPG measures continued..**

- Passive hip IR and ER
  - MDC = 5 degrees, RVPS 1.2 with hip flexion
- Hip abductor strength
- FABER
  - MDC= 8 degrees ROM and 1.6 RVPS
- Scour test
  - MDC= 1.6 RVPS

**CPG interventions**

- Manual therapy: superior to exercise in some however no more effective with highly limited function and pain.
- Exercise
  - Stretching/ ROM: focus on iliopsoas, rectus and hip adductors
  - Hip strengthening effective in reducing pain and improving function
  - Aerobic exercise shown to be helpful
Clinical Practice Guidelines for hip OA: comments on Aquatic Exercise

Level of evidence = II

“Patients who have an intolerance to land exercise due to pain or obesity may better tolerate aquatic exercise.”

“aquatic exercise has some short term benefits, long term benefits not documented”

Minor et al

• N=120 with RA (n=40) or OA (n=80) of hip, knee and ankle.
• Compared aerobic vs. non aerobic exercise
• 3 groups (met 3x week for 1 hour x 12 weeks)
  – Aerobic walking on land
  – Water aerobics
  – Control: non-aerobic stretching and strengthening
• Aerobic groups showed improvement in aerobic capacity, 50 foot walking time, depression, anxiety and physical activity
According to the American Academy of Orthopedic Surgeons...

Joint Replacement Surgery said to Increase!

- Aging baby-boomers
- Current obesity epidemic
- 69,007 TKA in 2006 estimated to increase to 3.48 million by 2030!
- THA said to increase to 572,000/yr. by 2030!

Clinical Decision Making

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Buoyancy

Therapeutic Benefits of Buoyancy

Decreased weight bearing/ decreased joint compression forces leading to decreased pain.

Decreased effects of gravity

Provides safe environment to perform passive, active assistive and resistive ex.

Drag Forces
Benefits of Viscosity
Strengthening muscles in both directions during an exercise resulting in balance of strength

Resistance can be controlled by speed and surface area, therefore progressive in nature

Slows movement allowing for improved quality, smoothing out jerky motions and provides increase time response for patients’ equilibrium reactions.

Benefits of Hydrostatic Pressure
Aids in the resolution of edema

Helps build up muscles of inspiration

In part responsible for reducing heart rate while in water.
Warm Water

Why Chose Water?

Why water?
- Control/ perfect motion
- Grade WB
- Trunk support
- Decreased stress to tissues

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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

Depth & Weight Bearing

<table>
<thead>
<tr>
<th>Water level</th>
<th>% WB</th>
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<tbody>
<tr>
<td>ASIS</td>
<td>50%</td>
</tr>
<tr>
<td>Xiphoid</td>
<td>30%</td>
</tr>
<tr>
<td>C7</td>
<td>10%</td>
</tr>
<tr>
<td>Over head</td>
<td>0%</td>
</tr>
</tbody>
</table>

Harrison & Bulstrode 1987

% WB with fast walking

<table>
<thead>
<tr>
<th>Depth of immersion</th>
<th>% WB</th>
</tr>
</thead>
<tbody>
<tr>
<td>C7</td>
<td>25%</td>
</tr>
<tr>
<td>Xiphosternum</td>
<td>50%</td>
</tr>
<tr>
<td>ASIS</td>
<td>75%</td>
</tr>
</tbody>
</table>

Harrison et al. 1992
Clinical Application

A 200 pound patient with a Knee replacement has pain when walking in waist deep water but tolerates walking quickly in chest deep water. How do you best communicate this information to the patient’s doctor?

Currently the patient is tolerating 50% weight bearing without increased symptoms, pain/ symptoms occur at 75% weight bearing.

When to Begin Aqua Therapy

Depends on surgeon guidelines (post-op)

Other factors to consider:
– Healing
– Functional status (if you do not have lift)
– Patient’s comfort level in the water
– Co-morbidities (HTN, diabetes, etc.)

Things to Remember with OA

• With hip OA if hip extension is limited be watchful for compensatory lumbar spine extension

• Even in the pool care should be taken to avoid weight bearing rotation

• Modifications of UE equipment may be required if OA is present in UE.
Research: Aquatic Therapy for hip and knee OA

Aquatic Therapy for patients with hip and/or knee OA

Effective intervention to ↓ pain and improve function
Silva et al (2008): 18wks, knee OA 3x/week
Foley et al (2003): 6 weeks, hip and knee OA 3x/week
Hinman et al (2007): 6 weeks, knee OA, 2x/week

Improved hip and knee flexibility/ strength and aerobic fitness, no effect on self-reported physical functioning and pain.
Wang et al (2007): 12 weeks in length

Aquatic Therapy post TKA

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Effects of Pre-operative exercise on TKA patients

• N=8 pre-op TKA patients
• Combination shallow and deep water exercise 3x week x 8 weeks 30-40 minutes each group session
• Statistically significant change in TUG
• General trend with increased knee flexion, hamstring strength and reduction in subjective pain score (however not statistically significant)


Integrated vs. Land only s/p TKA

(McAvoy, 2009)

• RCT, N=30, age 50-80 unilateral TKA within previous 6 weeks.
• Integrated group water 30 min and land 30 / session. Control = land exercise 60 minutes
• Both groups 2x/week for 6 weeks
• Compared NPRS, Girth measurements, ROM and Knee Osteoarthritis Outcome Score (KOOS)

Results of the pilot study

• Significant difference was found for knee flexion ROM and symptom score on the KOOS
• No significant change noted with pain, swelling and knee extension
• Should be noted that the baseline for the integrated group was lower than the land group.
Land-Based Vs. Water-based rehabilitation for subacute phase
(Harmer et al. 2009)

- N= 102 patients 2 weeks post TKA
  - Group 1 = water-based exercise 1 hour sessions 2 x 6 weeks
  - Group 2 = land-based exercise 1 hour sessions 2 x 6 weeks.
- Outcomes included: 6 min. walk test, stair climbing power, WOMAC scales, VAS pain rating, knee edema and knee ROM.
- Concluded a short-term land or water based rehabilitation delivered in the early phase after TKA was associated with comparable outcomes at the end of the program and up to 26 weeks pos surgery.

Water exercise performed in the Harmer study..

- Walking forward, backward and side-steps
- Step-ups
- Jogging
- Jumping
- Kicking
- Knee ROM exercises
- Lunges
- Combined squats with upper extremity exercise
- Performed approximately waist high deep water 25°C

Total Hip Replacement Research

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2012
Outcomes better for hydrotherapy group! (Giaquinto et al. 2009)

- Exercise and treatment 6 times per week for 3 weeks
  - Control group (n=33) had conventional gym
  - Hydrotherapy group (n=31)
- Outcome measure: WOMAC index
- Found both groups improved. Pain, stiffness and function were all positively affected. Statistical analysis indicated that WOMAC-sub-scales were significantly lower for all patients in the hydrotherapy group. The benefits at discharge still remained at 6 months.

Physical & Psychological Effects
(Weigenfeld-Lahav et al. 2007)

- 16 patients who had a THA at least 3 months before the study.
- Took part in a 6 week, two times per week, 30-45 minute aquatic therapy sessions. (performed in chest deep, water temp 33.4°C)
- All measurements: ROM, BBS, TUG, and QOL questionnaire improved.
- Concluded that aquatic therapy during the post-rehabilitation period of individuals with THA appears effective.

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Multicenter study comparing early vs. late aquatic therapy (Liebs et al. 2012)

- N= 465 undergoing THA (n= 280) TKA (n=185)
- Randomly assigned to receive aquatic therapy after 6 vs. 14 days after THA or TKA
- Primary Outcome is the WOMAC at 3, 6, 12 and 24 months.
- Secondary outcomes: Medical outcomes study 36-item Short-form Health Survey, Lequesne-Hip/knee score, WOMAC- pain and stiffness scores and patient satisfaction.

Results

- Total study population showed no statistically differences at follow up.
- Sub-analysis of for THA and TKA found opposite effects.
  - The WOMAC subscales were superior in the early aquatic group for TKA however, in the THA group the scores were superior in the late aquatic therapy group.

Inpatient Program Improves Strength (Rahmann et al. 2009)

- N= 65 (undergoing THA or TKA)
- Beginning on day 4 randomly assigned

- Measured strength, gait speed and functional ability at day 14.
  - Aquatic therapy
  - Water exercise (non-specific)
  - Ward therapy

- Hip abductor strength was significantly greater in the AT group compared to ward therapy or water exercise.
Aquatic therapy vs. Water exercise

Therapy group performed
At fast pace 80-88 bpm

Water exercise group
Worked at slower pace
50-58 bpm.

Therapy group performed specific lower extremity strengthening, trunk control and functional exercise

Benefits of DEEP water exercise

Decompress
Engage
Explore
Pursue

Therapeutic Benefits to Decompression

- Reduced pain
  - Increased ROM
  - Improved movement patterns
  - Greater tolerance to strengthening exercise
- Reduced risk
- Allows prevention of impairments of non-involved joints during healing process

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Shallow v.s. 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.
• Results support the use of deep water running for reducing compressive load on the spine while running.

Engage

• Without sensory feedback from the foot in contact with the bottom of the pool trunk muscles are engaged to align the body
• Balance and coordination
• Exercises: T-hang stabilization ex, dips, Jacks, sit and row

½ Diamond = 3 for one exercise
knee & hip ROM, hip dissociation & trunk stabilization
Vertical Position

- Stimulate function
- Promote alignment and elongation of the spinal column
- Challenges kinesthetic awareness for active trunk control
- Individual must use their trunk muscles in order to control rotation.
- Easier to initiate movement
- Head out of water

Explore

- Without a fixed point or fear of losing balance the client can explore a greater range of movement in all directions.
- Flexibility & Endurance
- Exercise: pendulums, hamstring stretch, figure 4 stretch

Length, stretch, control

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Therapeutic benefits/ Goals

- Increased freedom of movement
- Improved quality and quantity of movement
- Increased motor control
- Increased Flexibility
- Increased body position awareness

Pursue

- Because the body is not pushing off the pool floor the speed of movement is only limited by the strength of the client.
- Speed & Strength
- Exercise: x-ski, shoot through, barbell squats
Therapeutic benefits/ goals

• Increased strength and endurance
• Increased power
• Optimizing overall health with whole body conditioning/ maintain cardiovascular fitness while reducing risk of injury
• Enhance fitness and well being
• Improved compliance

Key points to alignment

Vertical position at rest

– Top of shoulder out of water
  • Otherwise risk impingement with buoyancy hand bar (dumbbell) use
– Neutral pelvis, spine and head
– Feet underneath hips
  • Think plumb line
– Requires adequate flotation

Deep Water Alignment

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Challenges to Deep Water Exercise

- Rotational forces
- Altered Kinesthetic cues
- Finding balanced Flotation
- Equipment usage and placement
- Primarily non-weight bearing and open chain for LE exercise

Floatation

- Equipment (Floatation vs. buoyancy)
  - Noodles
  - Vests
  - Cuffs
  - Belts
- Amount and location of floatation relates to relative density of the individual and their limbs
- Metacentric effect

Rotational Forces

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Sitting, kneeling and Standing

- Noodles
- Long bars/ barbells
- Burdenko Boards
- Wonder Boards
- Subskate
- Kickboards

Buoyancy Cuffs

- Different sizes
- Important to consider lever arm
- Significantly increases challenge to remaining vertical
- Caution when adding to program
Prone and Supine Recovery
Use physics

- Change surface area and relative density: Bring knees and arms in toward body
- Change COB and relative density: Exhale to assist in return to vertical

What happens when there is inadequate floatation?

- Tension
- Breath holding
- Treading water
- Interference with desired movement patterns

Breath Control with exercise

- Inhalation
  - Rib cage opens up and out while the spine extends
  - Use to facilitate thoracic extension, lifting the sternum
  - Use to increase buoyancy to gain desired movement
- Exhalation
  - Rib cage closes in and down and spine flexes slightly
  - Facilitates contraction of the abdominal muscles and spinal flexion.
  - Use to gain abdominal control during movement
Common Cues

- Relax hands and shoulders
- Gently press heels toward bottom of pool
- Lengthen the back of your neck/ bring chin in
- Gently lift chest to bring shoulders back, keeping stomach muscles engaged.
- Keep shoulders in line with your hips
- Squeeze gluts to bring feet underneath you

Precautions to Deep Water Exercise

- Hydrophobia
- Instability, poor trunk control,
- Limited/ Absent proprioception
- Early post-op spinal fusion
- Multi-level fusion
- SI joint hypermobility
- Ligamentous injuries
- Early post op hip replacement with dislocation precautions.

RESTORING FUNCTION AND GAIT
Quick Review
ROM Required for Functional Activity

• **Level Walking**: hip 15° extension/ knee 70° flexion and full extension
• **Climbing Stairs**: hip flexion 67°/ knee flexion 83°
• **Arising from a chair**: hip flexion 112°/ knee 93°
• **Standing straight**: knee full extension/ hip extension to at least neutral.

Increasing knee and hip flexion ROM

Hamstring stretching
More aggressive knee flexion ROM and quad stretch...

Gait

What is different about walking in the water?

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.

• Normal and fast speeds in pool significantly slower compared to land
  * Fowler-Rhyme, A 2000
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)
  
Muscle Activity with Water Walking

- Hip extensors working greater concentrically LR to mid stance vs. eccentrically to control flexion torque.
- Hip flexion assisted during swing (with slow movement)
- Hamstring eccentric activation at terminal swing and loading response not as great due to assist from buoyancy.
- Quadriceps greater resistance mid-swing to terminal swing due to drag forces
- Ankle Dorsiflexors assisted by buoyancy both during swing and at loading response.

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 gastocnemius muscle activity was higher compared to land.
- 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.
- 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)
Gait comparisons THA vs. TKA
(Giaquinto 2007)

Concluded “TKA patients were balanced over their feet and appeared more cautious and more concerned about gait quality than moving quickly. By contrast, THA patients were unbalanced, having longer stance phase on non-operated leg and longer swing on contralateral one. However, their speed gain was higher.”

Clinical Application
Aquatic Gait Training

• Assess gait on land first if possible
• Shoe wear is important
• Slower speeds compared to land
• Don’t forget to walk in multiple directions
• “core”/ trunk strength can not be ignored
• Common deviations/ compensations made in the water are often due to buoyancy and drag forces
• Utilize equipment when needed for stability

Early gait training: noodle scoots

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Balance and Postural Control

- Stability
  - Control of COM relative to BOS
- Orientation
  - To maintain the appropriate position of the entire body with respect to the environment and the task

Individual Sensory Systems
- Sensory Strategies
- Adaptive Mechanisms
- Anticipatory Mechanisms
- Postural Control
- Musculoskeletal System
- Neuro-muscular Synergies

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Cognition and Perception

• Fear of falling leads to decreased activity, reduced mobility and fitness, in turn increasing risk for falls

• Cognition does play a role in processing sensory information.

Self Reported Scales

• Activities-Specific Balance Confidence
• Modified Falls Efficacy Scale

Postural Stability Requirements

› Able to determine movement of COG

› Balance responses triggered by availability and accuracy of the sensory inputs

› CNS weighs input from 3 primary sources

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Total joint Specialty Certificate Course

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Somatosensory Inputs

Focal and Ambient Vision

Vestibular Input
Movement Strategies for Controlling Upright Sway

- **Ankle strategies**
  - Used during quiet stance or secondary small perturbations on normal support surface
  - COM shifts to and from by rotating body about ankle joints
    - 15° fwd and 7° bwd
  - Muscle activity initiates distally at the ankles and then radiates to the thigh and abdominal muscles

Motor Strategies

- **Hip Strategies**
  - Surface shorter than foot length
  - Unstable surfaces
  - Movement near limit of stability
  - Fast sway
  - Larger perturbations
  - Muscle activated in proximal to distal

Motor Strategies

- **Stepping strategies**
  - Occurs when the LE and trunk cannot maintain the COG within the BOS
  - A step will increase the BOS or realign it
Musculoskeletal Impairments

- Decreased ROM and strength
- Altered proprioception
- Pain

Adaptive Postural Control

Anticipatory Postural Control
Fall Risk

Medicare Population Fall Estimates 3.7-3.1 million in 2002 with 2.2 million medically injurious
(Shumway-Cook 2009)

Evaluate and Measure

Balance Tests

- Berg Balance Scale
- Tinetti Performance Oriented Mobility Assessment
- Sit to stand/Chair raise test
- Step test
- TUG
- SLS
- Dynamic Gait Index
- Romberg/sharpened Romberg
- CTSIB
- BESTest (Balance Evaluation Systems Test)
Aquatic Research Summary

- Often done in group setting
- Land ex often same as water
- 2-3 x/ wk, 40-60 minute sessions, ranged from 4 weeks to 20 weeks
- High compliance and perceived outcomes with water exercise
- Land and water programs had similar results
- Education and functional practice important
Specificity

You get what you train

Challenge Balance

- Wide to narrow BOS
- Double leg to single
- Stable to unstable surface
- Eyes open to eyes closed
- Movement in multiple planes
- Work in multiple postures & functional activities
- Add head turns
- Anticipatory tasks (throw a ball)
- Reactive tasks (perturbations)
- Dual task
  - Add Mental task
  - More than one physical task

Pool Techniques to Challenge Balance

- Perturbations
  - Manual
  - Self turbulence
  - External turbulence
    - Push
    - Scoop
- Stop/ start quickly and hold
- Change direction
- Immerse above T11
Equipment and Pool Progressions

Deep/ suspended
  Belt- belt and light buoyancy cuffs – hydro-cuffs
  Closed chain with noodle, barbell, kickboard

Shallow
  Deeper to more shallow
  Sometimes shallow to deeper (<T11)
  Static balance to dynamic
  Increased resistance with increased speed, addition of drag force equipment or tubing

Documentation/ Quantifying Balance Progression in the Pool

• General functional balance grades
• Clinical observations
  – Stability
  – Use of arms/ sculling with hands
  – Amount of postural sway
  – # of times LOB
  – Required assist to recover balance
• Compare to performance on land
  – Independent vs. C.G.A. or min assist etc.
  – Willingness to perform activity

Training Balance under Single and Dual-Task Conditions

• Research concluded:
  – Patients who received balance training under dual-task conditions showed dual task training benefits
  – These benefits were maintained for 3 months
  – The patient who received variable-priority training showed improvement on novel tasks.
  – Silsupadol et. al (2006)
Dual Task Challenges

Pool Safety
- Locker rooms
- Wet floor
- Sharing public space
- Precautions

Patient Education
- Assistive device
- Transfer techniques
- Home adaptations
- Awareness

* When a patient is high risk, fall prevention education should take priority.
Questions?

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