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Hip and Knee Arthritis to Joint Replacement: Aquatic Therapy Research Review and Clinical Application

Beth Scalone PT, DPT, OCS, ATRI
beth@waterpt.com

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Objectives:

- List at least three risk factors for developing symptomatic OA.
- Describe at least three therapeutic benefits of buoyancy, drag forces and hydrostatic pressure.
- Identify the 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.
- Outline at least three aquatic exercises to increase mobility, function and gait

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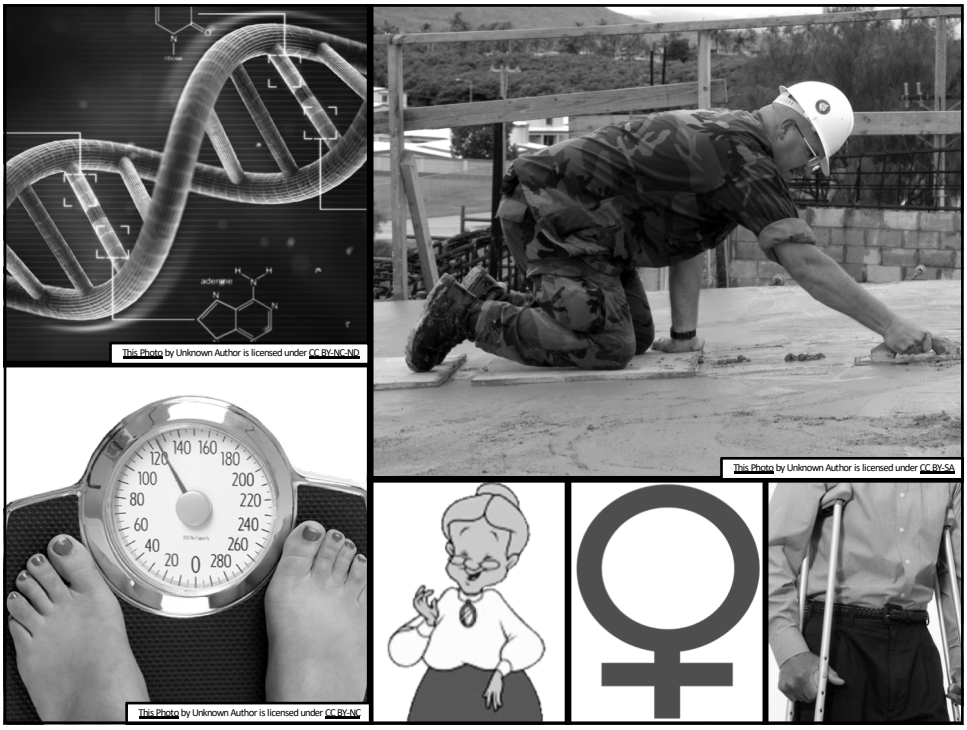
According to the Arthritis Foundation www.arthritis.org

54 million adults have doctor diagnosed arthritis, 31 million with osteoarthritis

Cost the U.S. economy in 2013 was $140 billion

Arthritis is the leading cause of disability in the United States



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Risk Factors Knee OA

(Felson et al. 1997/Blagojevic 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/ 2017)

Age
Hip Developmental Disorders (CHD, Legg-Calve Perthes, slipped capital femoral epiphysis)
Previous hip injury

Reduced ROM (especially IR)
Presence of osteophytes
Lower socioeconomic status
Higher bone mass and BMI

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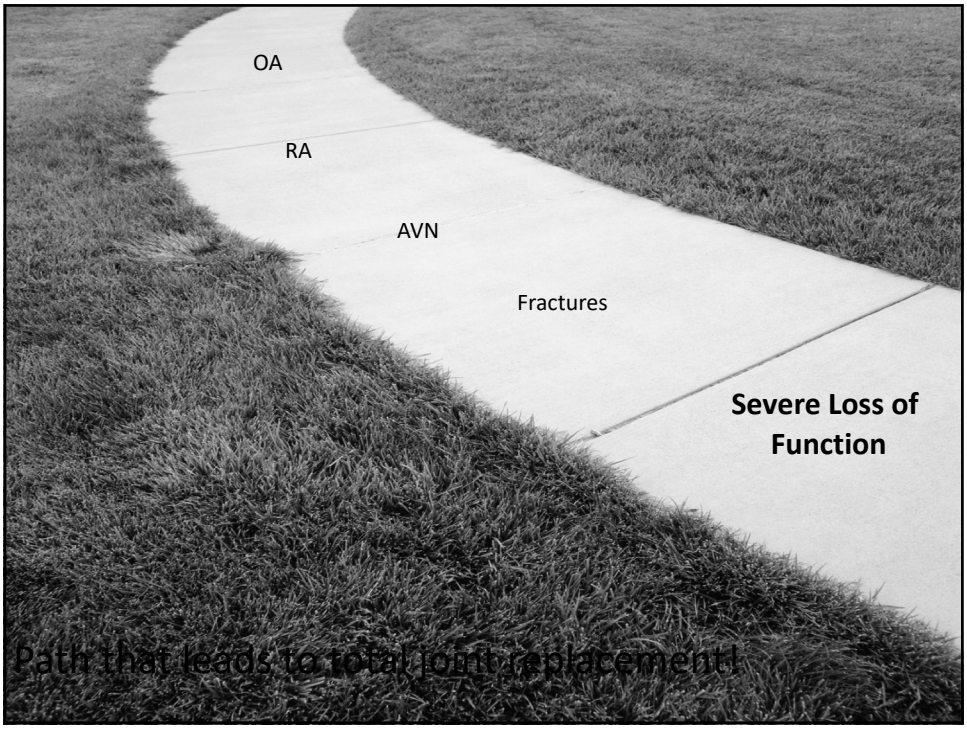
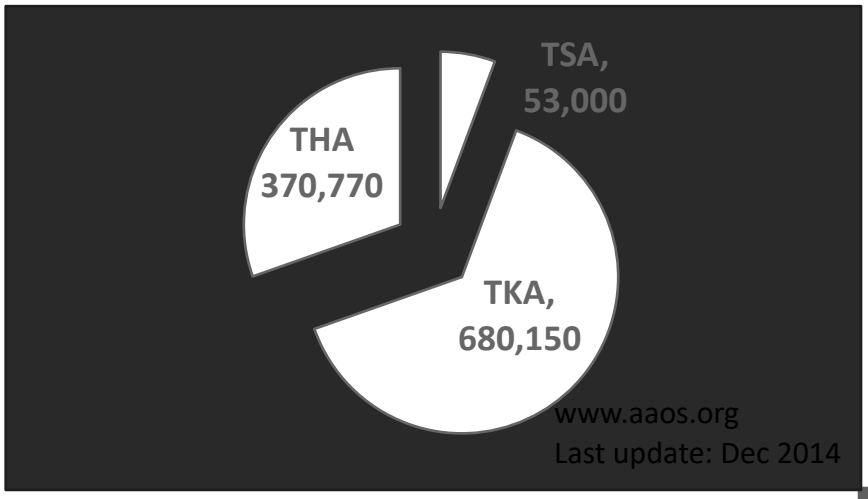
Argument for Weight Management

- "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
- 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)



According to the American Academy of Orthopedic Surgeons…



Joint Replacement Surgery on the Rise!

- 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!

Kurtz et al. 2009

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CONTINUED

Clinical Decision Making

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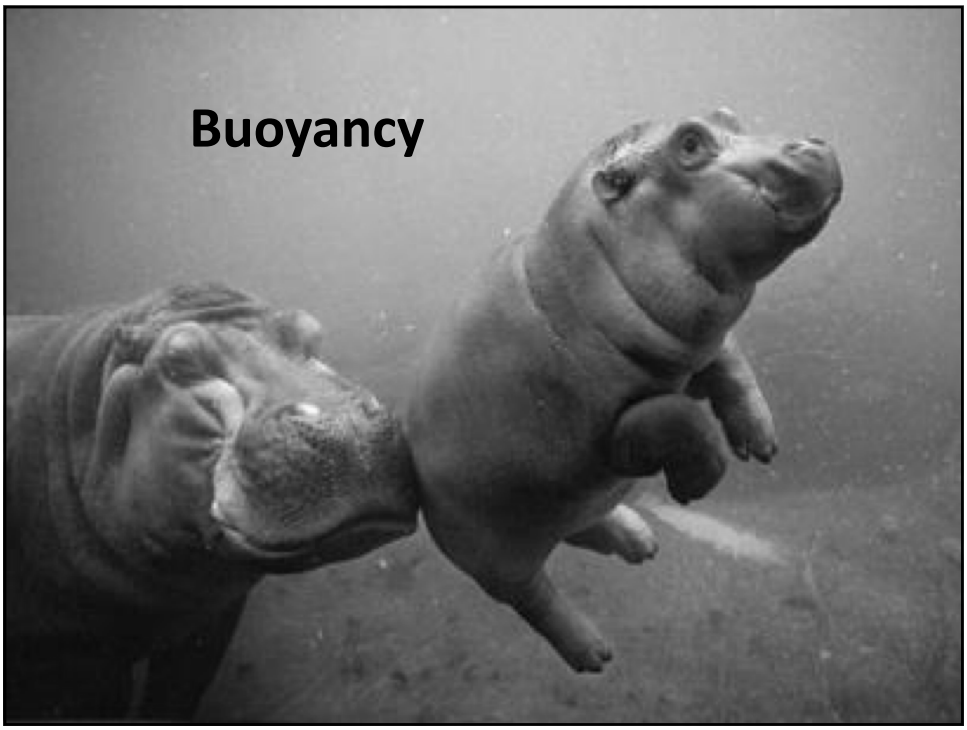
Why choose water?

- Control/ perfect motion
- Grade WB
- Trunk support
- Decreased stress to tissues
- Safety/ especially for fall risk
- Reduce edema
- Increase blood flow



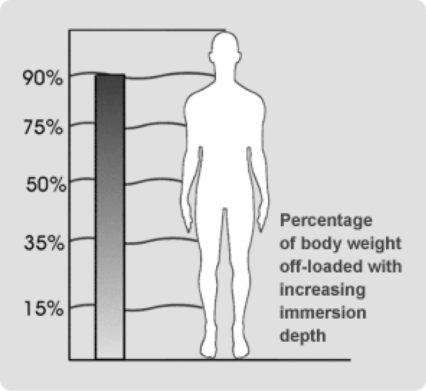
Therapeutic Benefits of Buoyancy

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.

Depth & Weight Bearing



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

Harrison and Bulstrode 1987

% WB with fast walking

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

But what happens with fast walking and running?

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

Running in the water decreases stress on the body
(Fontana et al 2012)

- Running at hip level decreased the forces 40%
- Running at chest level decreased the forces 50%
- When running on land forces were greater with faster running speeds
- Forces did not increase with increased speed when running in the water
- The ability to decrease the forces was similar for both men and women

Drag Forces

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

- 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)

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.

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.

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.

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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.

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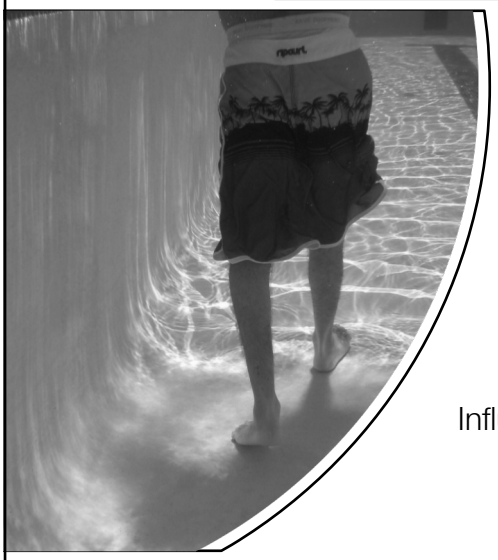
Effects of Edema

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.



Water Walking

Influenced by Buoyancy and Drag

Gait training using water…

- Reduce antalgic compensations
- Analyze deviations on land first
- Muscle activation is different
- Cadence/ step length changes
- Spatio-temporal relationship stays the same 60%/40% swing/ stance

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Differences when walking in 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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Muscle Activation

- Hip extensors working greater concentrically LR to mid stance vs. eccentrically to control flexion torque.
- Hip flexion assisted during swing
- 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.

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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.

Normal and fast speeds in pool significantly slower compared to land

Fowler-Home, A 2009

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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CONTINUED

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.
- 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)

Musumoto &Mercer 2008

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CONTINUED

Research Review

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- Practice guidelines and recommendations
- Aquatic specific research and outcomes
- Clinical applications from the research

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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)

Research:

Aquatic Therapy for hip and knee OA

Article authors: Ruiz Santiago, Fernando; Santiago Chinchilla, Alicia; Ansari, Afshin; Guzmán Álvarez, Luis; Castellano García, Maria del Mar; Martínez Martínez, Alberto; Tercedor Sánchez, Juan [CC BY 4.0 (https://creativecommons.org/licenses/by/4.0)], via Wikimedia Commons

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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.

Systematic Review/ Meta-Analysis of 10 studies (Batterham, Heywood and Keating 2012)

Concluded:

"Outcomes following aquatic exercise for adults with arthritis appear comparable to land based exercise. When people are unable to exercise on land, or find land-based exercise difficult, aquatic programs provide an enabling alternative strategy."

Aquatic Therapy for patients with Hip and/ or Knee OA

Effective intervention to ↓pain and improve function

Silva et al (2008): 18 wks, 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

CONTINUED

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.

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Hip OA Clinical Practice Guidelines

Orthopedic Section of the APTA
(Cibulka 2009/ 2017)

- 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

30 minutes 60-80% of max HR

Aerobic groups showed improvement in aerobic capacity, 50-foot walking time, depression, anxiety and physical activity

Aquatic Therapy post TKA

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)
  - Winter, SV, Burch, D. (2000)

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 sub-acute 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 post 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

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 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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Research Review
Aquatic Therapy
Post Op
THA & TKA

CONTINUED

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

Water Rehab Program in patients with hip OA before and after THA

Typ, M et al. (2016) Medical Science Monitor 22:2635-2642.

- Rehab programs including water exercise most significantly reduced pain in patients with hip OA before and after THA.
- The addition of water exercises in the rehab program reduced the use of medications
- ROM and strength also improved in the exercise groups, greater in water exercise compared to controls.

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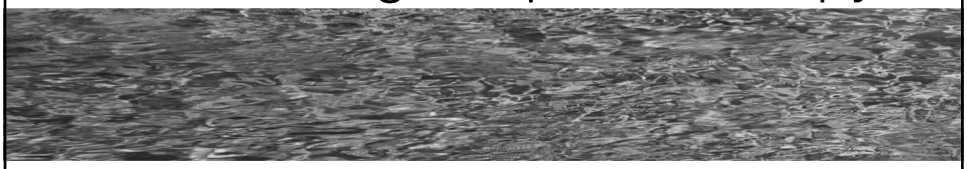
When to Begin Aquatic Therapy?



Depends on surgeon guidelines (post-op)

Other factors to consider:

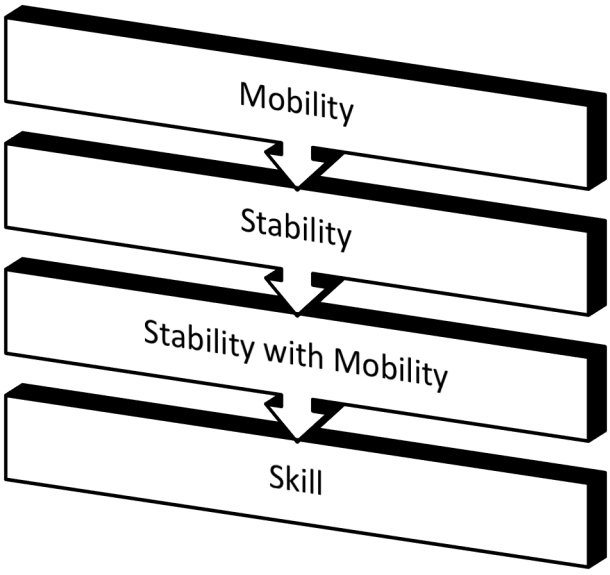
- Healing
- Functional status (if you do not have lift)
- Patient's comfort level in the water
- Co-morbidities (HTN, diabetes, etc..)

Clinical Pearls for OA and TKA/THA

- Motion is the lotion
- Hip/ core strength essential
- Quad and ankle flexibility play big role in ROM
- TKA: edema control is vital to restoring ROM. Need full extension for normal gait
- THA: precaution compliance PRN, stability in gait, functional mobility

Possible Complications post-op

- Fracture: usually from a fall or other traumatic event (MVA)
- Pain: possibly from slippage or wear of joint
- Infection: important to be aware and look for signs/symptoms of infection
- Dislocation
- Blood clot: be aware of signs/symptoms



ROM

According to AAOS the expected range of motion after a TKA is 115 degrees

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.

What you see is what you get? NO!

What you see on the outside is not what they cut on the inside!

Why is that important?

Increasing knee and hip flexion ROM

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More aggressive knee flexion ROM and quad stretch…

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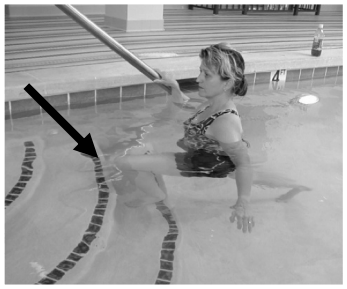

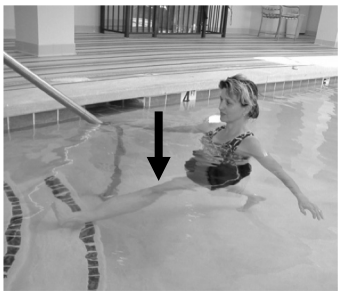

Full range and good form!

Tricks for the stiff knee

Let's talk stretches….

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Size of noodle matters!

Buoyancy Cuffs and Equipment

Different sizes

Important to consider lever arm

Significantly increases challenge to remaining vertical

Caution when adding to program

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Anchors Away! Stability for Functional Movement

Grounding:
Finding Stability in a Buoyant Environment

Weight shift (all directions), positional awareness, core activation

Rhythmic stabilization

Partner miming

Heavy concept

Need for both shallow water & deep-water activities

Rhythmic stabilization (PNF)

Utilizes alternating isometric contractions of first agonists, then antagonists against resistance; no motion is allowed. Slow build and slow release.

Think of it as 'waking up' muscles you want to fire!

Partner Miming

Partner Miming Progressions

- Seated
- Standing
- Staggered stance: add heel and toe lift
- Single leg
- Walking forward

CONTINUED

Heavy Concept

Heavy Concept – think heavy before using upper or lower extremities, or trunk or head

- Teaches proximal to distal movement
- Use "reverse heavy" during extension

Clinical Purpose

- Increase re-patterning in terms of moving proximal to distal
- Increase energy cost (with increased muscular recruitment)
- Assist in overall balance and coordination.

CONTINUED

Slow and Hold

Stillness in water and Yoga poses

Slow motion

Creates stability

This along with stop start decreases the controlled fall forward.

Stop start

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In addition to quadriceps, what muscles need to be strong?

What muscles are often weak?

Why?

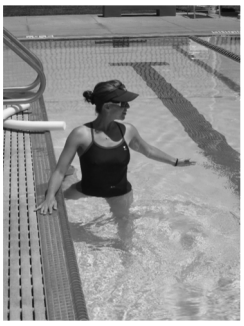
Gluteal Amnesia!

Need to gain flexibility in the hip flexors, quadriceps and ITB before gluts have a chance to turn on again!

In a systematic review that included 5 studies the researches found moderate quality of evidence that people with knee OA have significantly weaker hip abduction (up to 24% isometric strength).

Hip strength assessment should be considered in clinical practice in those diagnoses with knee OA.

Deasy M, Leahy E, Semciw A. (2016) Hip strength deficits in people with symptomatic knee osteoarthritis: A systematic review with meta-analysis. *Journal of Orthopedic and Sports Physical Therapy.* 46(8) 629-639


Glut Medius Strengthening

Turning on the gluts

Exercise
- Basic isolated glut max/ medius and minimus
- Stretching tight hip flexors and ITB
- Single leg activities with good alignment
- Advanced integrated/ cross-body body connection

ADL modification
- Pillow between legs when sleeping on your side
- Avoid crossing legs
- Stand up at least every hour

CONTINUED

Drag force and tubing….

https://beaqua.com.sg/product/aqualogix-resistance-fins/

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Restoring Function and Gait

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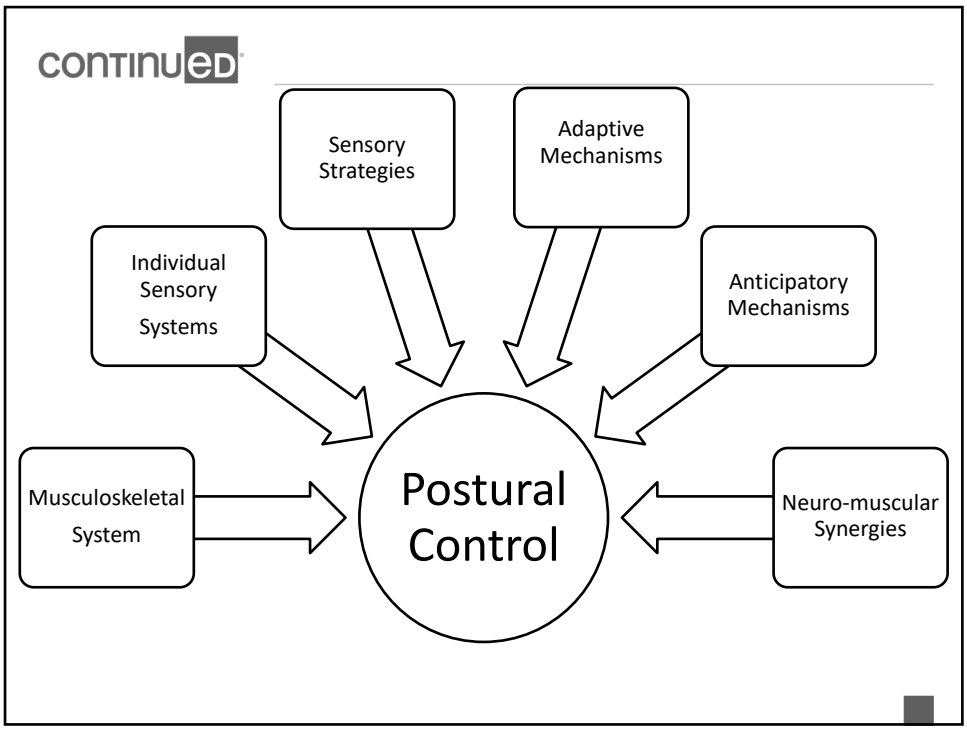

Cognition and Perception

- 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

CONTINUED

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

Education and Functional Training

Arnold & Faulkener 2010
Arnold et al. 2008

CONTINUED

Research:
Core Strength & Balance

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
    - Therapist run around
- Stop/ start quickly and hold
- Change direction
- Immerse above T11
- Slow motion

CONTINUED

Clinical Pearl for stability focused pool exercise: Keeping your ducks in a row…

CONTINUED

Gait and functional mobility

- Sit to stand: ROM, glut strength, squats
- On off the floor: lunges, balance in ½ kneel
- Steps: squats, single leg squats, step ups, single leg balance with opposite leg lift.
- Gait: knee extensions at IC, weight shifts, single leg stance ability, balance in staggered stance

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CONTINUED

Early gait training: noodle scoots

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.

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