Aquatic Intervention for Patients with Lower Extremity Osteoarthritis

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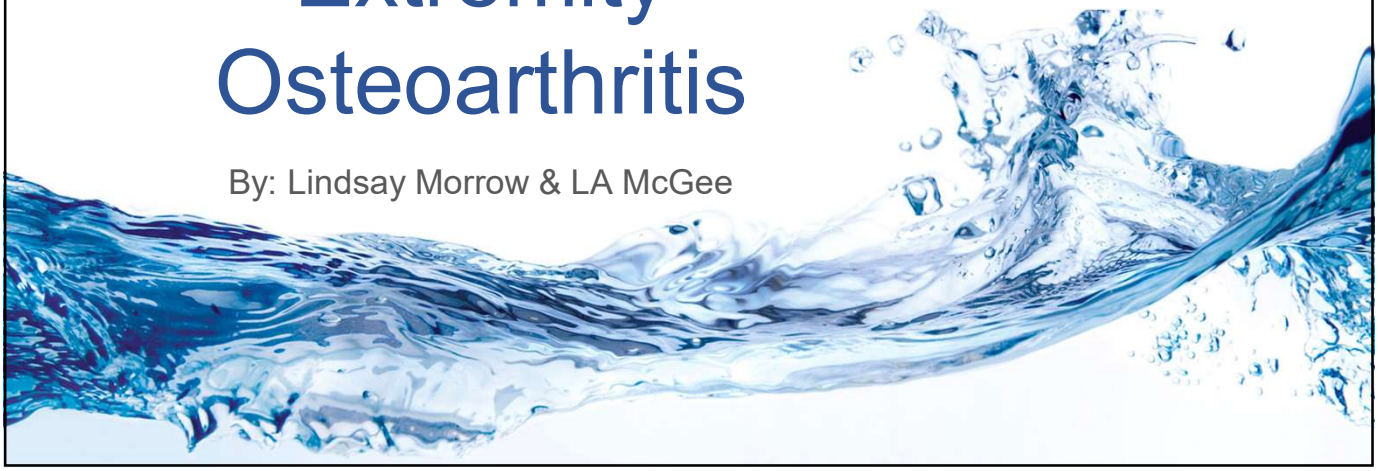


Objectives

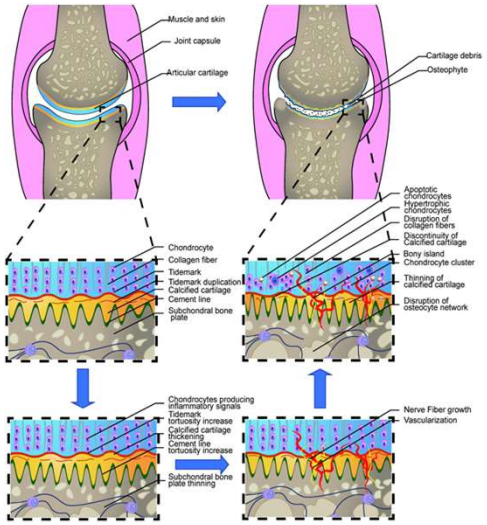
- Describe normal joint physiology, etiology, incidence, pathophysiology, clinical presentation, conservative therapy, and prognosis of osteoarthritis.
- Provide information that is up to date and based upon current recommendations for those with lower extremity osteoarthritis.
- Deliver recommendations and educational information to other medical providers treating a population with osteoarthritis.
- Educate providers and students on aquatic therapy and its role in the treatment of osteoarthritis.
- Outline the evidence for utilizing aquatic therapy before and after having a joint replacement surgery.

What is Osteoarthritis (OA)?

- OA is a common joint disorder affecting around 43 million affected patients in the United States alone and about 15% of the world population.[1]
- OA is a multifactorial disease affecting the whole joint (subchondral bone, synovium, menisci, ligaments, periarticular muscles and nerves), not just articular cartilage.[1]
- OA becomes symptomatic when the repair processes are maladaptive and cannot keep up with the rate of micro/marco injury.[2,3]
- Understanding the pathogenesis of OA can be crucial for initiating early and effective preventative treatment to slow disease progression and reduce symptoms.

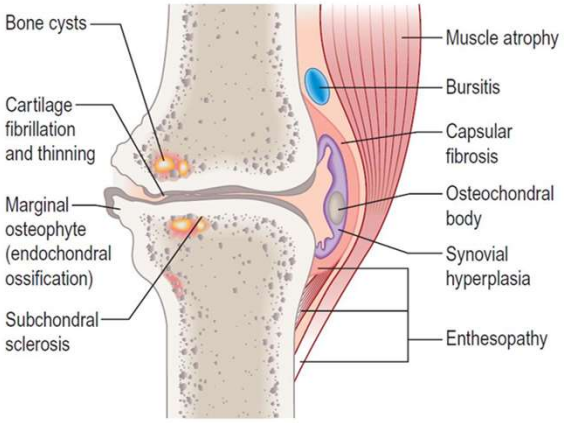
Pathogenesis of OA on Articular Cartilage[1]

- Caused by chondrocyte failure in maintaining homeostasis between synthesis and degradation of extracellular matrix components (water, collagen, proteoglycans and a very small component of calcium salt and chondrocytes).
- This disruption of homeostasis results in:
  - Increased water content.
  - Decreased proteoglycan content of the extracellular matrix.
  - Weakening of the collagen network due to decreased synthesis of type II collagen.
  - Increased breakdown of pre-existing collagen.



Pathogenesis of OA on Subchondral Bone[1]

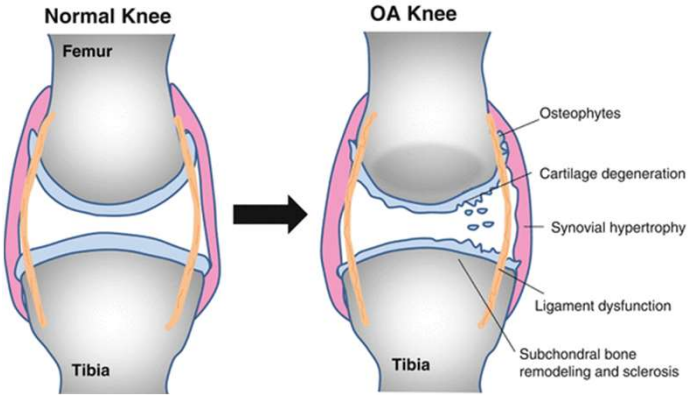
- Alterations in the bone remodeling process leads to changes in subchondral bone structure.
  - Alterations include: Progressive thickening of the subchondral bone plate, formation of osteophytes, bone cysts, bone necrosis in late stage OA.
- Abnormal mineralization patterns lead to a stiffer structure that is not as capable of absorbing/dissipating energy.
- This then increases force through the joint which could lead to further deformation.



Osteoarthritis

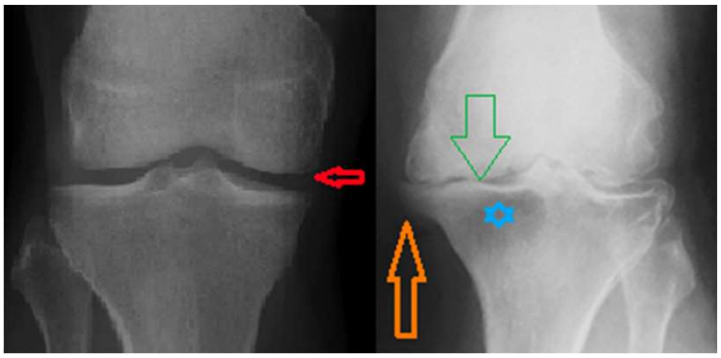
Pathogenesis of OA on Synovial Membrane & Menisci[1]

- Synovial membrane
  - Thickening of the synovial lining cell layer and increased inflammatory cell infiltration (worsens with increased severity).
- Menisci
  - Type I and II collagen decreases while proteoglycan content increases, leading to meniscal degeneration and reduced meniscal tensile strength.



Diagnosis of OA

- Patients must have the following:[4]
  - Osteophytes on radiographs
  - Joint space narrowing
  - Average severity of pain of greater than 3 cm on a 10-cm visual analog scale (VAS)
  - Difficulty with daily function tasks (walking, stair, getting up/down from chair)

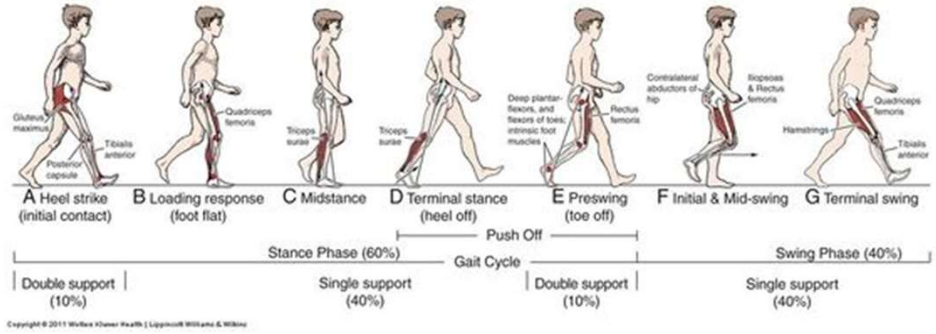


Common Knee OA Attributable Impairments

- Weakness/Atrophy
  - Quadriceps
    - Quadriceps weakness is an extremely common deficit among patients with knee OA.[5,6]
      - 10-56% deficit in isometric quad strength[6]
    - Quadriceps strength is a predictor of symptomatic knee OA as well as functional performance on the TUG, SCT, and 6MWT post Total Knee Arthroplasty (TKA).[6,7]
  - Hamstrings
    - 4-35% hamstring isometric strength deficits.[6]
  - Global hip musculature
    - Hip muscle isometric strength deficits
      - 16% extension, 27% external rotation[6]
    - Hip muscle concentric isokinetic deficits
      - 22% hip abduction, 64% hip extension[6]

Common OA Attributable Impairments (cont)

- Decreased force generation capability
  - Due to decrease quadriceps cross sectional area and impaired sensory organs in knee.[6]
- Movement pattern/ gait abnormalities (variable)
  - Antalgic gait
  - Step to gait (decreased stance on involved side due to weakness and/or pain)



Common OA Attributable Impairments (cont)

- Decreased Function
  - Highly dependent on degree of OA and pattern(s) of weakness.
  - Over 50% of those with OA will have TKA during their life.[8]
  - Those with OA will have a 40% to 50% increased risk for disability.[9]
  - Those with chronic OA may have moderate to severe limitations in activities such as walking, stair climbing, and transfers.[10]
  - Over 33% of those with arthritis will have an arthritis-attributable work limitation.[11]
  - 30% of adults with arthritis find stooping, bending, or kneeling very difficult.[12]
  - 20% of those with OA are unable to or find it very difficult to walk 3 blocks and push/pull large objects.[12]

Common OA Attributable Impairments (cont)

- Decreased Participation
  - Avoidance of physical activity.[10]
  - Over 33% have an arthritis-attributable work limitation. [11]
  - 19.9% report having arthritis- attributable social participation restrictions.[11]
- Decreased QOL
  - People with OA are at a greater risk of developing anxiety and depression.[13]

Recommendations Per The American College of Rheumatology/Arthritis Foundation OA CPG[14]

Aquatic therapy →

Intervention	Joint	
	Knee	Hip
Exercise		
Balance training		
Weight loss		
Self-efficacy and self-management programs		
Tai chi		
Yoga		
Cognitive behavioral therapy		
Cane		
Tibiofemoral knee braces	(Tibiofemoral)	
Patellofemoral braces	(Patellofemoral)	
Kinesiotaping		
Hand orthosis		
Hand orthosis		
Modified shoes		
Lateral and medial wedged insoles		
Acupuncture		
Thermal interventions		
Paraffin		
Radiofrequency ablation		
Massage therapy		
Manual therapy with/without exercise		
Iontophoresis		
Pulsed vibration therapy		
Transcutaneous electrical nerve stimulation		

Strongly recommended
Conditionally recommended
Strongly recommended against
Conditionally recommended against
No recommendation

Per the CPG chart, exercise, balance training, and weight loss are strongly or conditionally recommended for both knee and hip OA, all of which can be facilitated by using aquatic therapy.

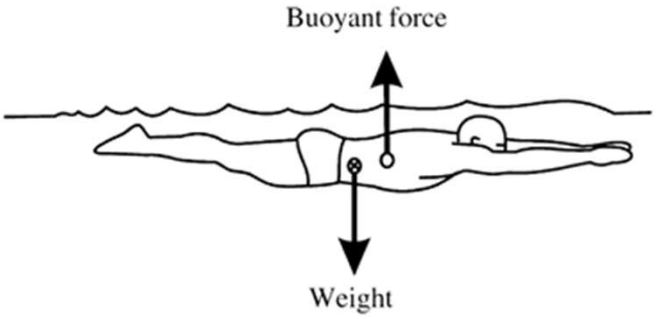
Aquatic Therapy Per the CPG's

- There is strong evidence suggesting that aquatic therapy is efficacious in reducing pain and improving function, but it is only a "conditional recommendation" due to barriers in feasibility and accessibility.[2, 5,13,14]
- Beneficial for when exercise is too painful or too difficult to do on land.[5]
- Good for patients with symptomatic OA due to the pool being a low impact environment.[13,15]
- Allows completion of the following components of fitness recommended for OA:
  - Full body resistance
  - Aerobic exercise
  - Stretching/flexibility
  - Functional movements
  - Ambulation
  - *Utilize a combination of above for optimal results.[5]

General Benefits of Aquatic Therapy

Buoyancy: The force that opposes gravity when the body is partially or fully immersed in water (aka minimizes vertical ground reaction force).

- Decreases the stress on weight bearing structures (unweighting) that results in the patient being able to perform exercise with less trauma to the joint and subsequently less pain.
- Can act to assist ROM in patients who cannot lift extremities against gravity (AAROM).
- Enables the use of flotation devices to aid static stretching by allowing the patient to "relax" into the stretch.



General Benefits of Aquatic Therapy (cont)

Temperature: Warm or cold effects on vascular tone and tissue metabolism can address the different inflammatory stages of OA.

Warm (35-40 deg C)

- Can block nociception by acting on local thermal receptors and mechanoreceptors, thus influencing spinal segmental mechanisms.[16]
- Increases the release of endogenous opioids.[17]
- Causes vasodilation which reduces the peripheral vascular resistance and increases tissue perfusion may improve muscle relaxation.[16]

Cold (8-10 deg C)

- Produces a central redistribution of blood volume due to pronounced peripheral vasoconstriction.[18]
- Relieves pain through reducing nerve conduction velocity and inhibiting nociceptive receptor sensitivity.[19]
- Reduces blood flow to the extremities which aids in dissipating inflammatory mediators associated with local inflammation and pain.[18]

General Benefits of Aquatic Therapy (cont)

Hydrostatic Pressure: The pressure exerted by the water on a body immersed in that water.

- Promotes circulation by varying the pressure exerted on the body according to the immersion depth, which results in increased blood flow to major organs (the heart, brain, and lungs).[20]
- Promotion of diuretic action (diuresis during immersion is 2.5–3 times higher than in the pre-immersion period).[20]
- Can relieve pain by dampening sympathetic nervous system activity.[16]
- Can reduce peripheral edema or swelling through pressure exerted at various depths.[21]
  - More depth = more pressure
- Supplies full body resistance to improve muscle strength, flexibility, and can reduce falls risk.[22,23]

General Benefits of Aquatic Therapy (cont)

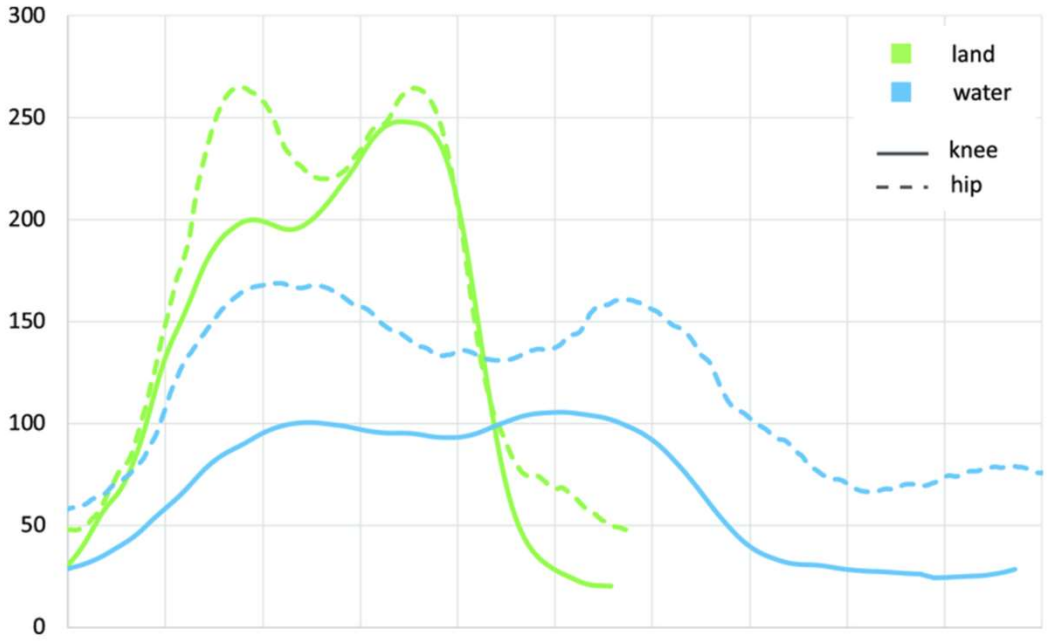
Viscosity: Provides constant resistance that can be manipulated based on the amount of surface area in order to change exercise intensity.

- Allow for muscle strengthening with decreased joint stress
  - Less surface area = less resistance applied

Summary of Aquatic vs Land Therapy Evidence

- There is mixed evidence regarding whether aquatic or land based interventions are more efficacious for those with lower extremity (LE) OA.
- Both land and water exercise have been found to improve: knee ROM, thigh girth, pain, walking speed, stiffness, stability, balance, LE strength, stair climbing time, and function.[24-30]
- Overall, there is not a major nor consistent difference between land and aquatic interventions, but some studies give preference for aquatics.
  - The RCT by Silva et al.[26] reported that hydrotherapy was superior to land based exercise in regards to pain relief before (P=.009) and after (p<.000) walking.
  - The RCT by Wyatt et al.[31] found that after 6 weeks of aquatic intervention, the aquatic therapy group had significantly better improvements in pain reduction than the land intervention group.

Main takeaway: Determining mode of therapy (land vs water) may be based on patient preference and the resources available.



Resultant hip and knee joint force (F res) patterns during walking on land and in water. Average force pattern of all subjects. BW = bodyweight. https://doi.org/10.1371/journal.pone.0171972.g004

Who is Appropriate for Aquatic Therapy?

- Osteoarthritis[4]
- Pre and post-operative
- Chronic Pain
- Fibromyalgia
- Spinal cord injury
- Joint replacement
- Sports injuries
- Chronic swelling
- Obesity
- Stroke

Contraindications For Aquatic Therapy

- Extreme fear of water[32]
- Open/draining wound[32]
- Uncontrolled hypertension[34]
- Flu/vomiting[33]
- Severe dermatological problem (impetigo, draining herpes)[32]
- Symptomatic cardiac failure with low ejection fraction[32]
- Tracheostomy[33]
- Fever over 100 degrees F[32]
- Frailty[2]
- Involuntary diarrhea or bowel incontinence (must be diarrhea free for 2 weeks)[32]

Parameters/Prescription of Aquatic Therapy

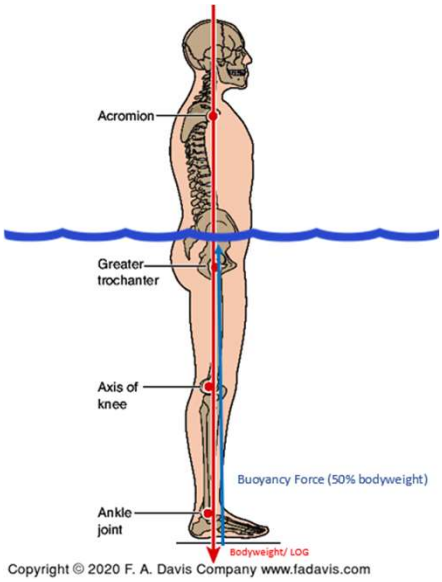
- Aquatic therapy can be used alone or in addition to land based exercise, with the goal of meeting the ACSM guidelines:
  - 150 minutes of moderate intensity physical activity, plus 2 strength training sessions per week
- Frequency
  - 2-3 sessions per week[5]
- Intensity
  - Moderate Intensity (50-70% Max HR)[5,13]
- Time
  - 30-60 min duration[5]
- Type:
  - Utilize combination of aerobic, strengthening, resistance, and flexibility.[5]
  - Progressive exercise with focus on functional activity, such as walking, is key for recovery.[5,7]
  - The quadriceps and biceps femoris are the key muscles that require strengthening to improve the stability of OA knees.[7,31]

Parameters/Prescription of Aquatic Therapy (cont)

Submersion depth depends on desired level of intensity, desired purpose of exercise, weight bearing tolerance, and degree of pain.[36]

<u>During static standing:</u>

- Waist deep water= 50% weight-bearing
- Neck deep water= 10% weight-bearing
- Xiphoid deep water= 30% weight-bearing



When is surgical intervention recommended?

The decision is ultimately up to the patient, but the following factors are considered when determining if a joint replacement is recommended:

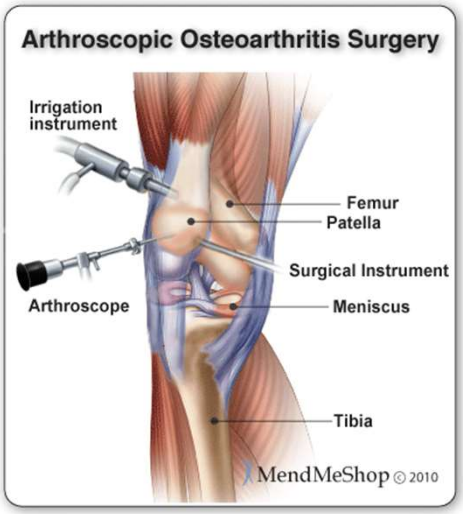
- Pain[37]
- ROM deficits[37]
- OA stage[37]
- Patient related-factors (age, level of physical activity, and patient's comorbidities)[36]
- Interference with functional activities[37]
- Failure of conservative care interventions[38]

Surgical intervention is always a “relative” indication and is most often indicated with radiological evidence of OA (joint space narrowing, osteophytes, etc.), consideration of the patients degree of suffering, and the other aforementioned factors.[37] Radiological evidence alone does not justify surgical intervention.

The only potential case where surgical treatment for OA should not be delayed is in the presence of progressive knee instability.[1]

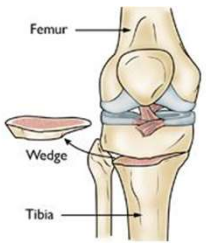
Surgical Options[39]

- Arthroscopic
  - Advantages: Allows less invasive access to joints and the opportunity to intervene earlier in the course of joint destruction.
  - Indication: Most common indication is for patients with knee OA and a concomitant meniscal tear.
    - Patients who have had an arthroscopic partial meniscectomy (APM) have earlier and more severe OA than age matched patients who have not had an APM.
  - Overall consensus: Arthroscopic lavage and debridement are not very useful for the management of OA in the absence of a superimposed structural lesions, such as a meniscal tear.



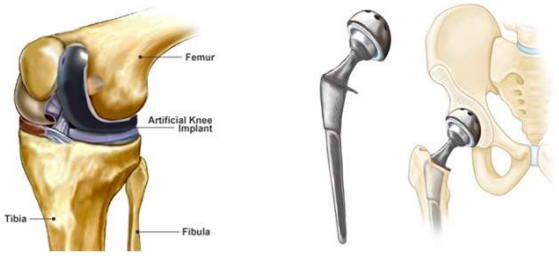
Surgical Options (cont)[39]

- Osteotomy
  - Advantages: Restore a more anatomic biomechanical environment (alignment) and prevents or delay the onset of OA or slow its progression by shifting load from damaged compartments to healthy compartments
  - Indications: Primarily used in younger patients with predominantly unicompartmental OA.
    - Also used as an adjunct treatment for cartilage repair procedures to normalize the biomechanical environment.
  - Overall consensus: Osteotomy is not as effective as total knee replacement in relieving pain and osteotomy fails sooner than TKA on average, prompting additional surgery.



Surgical Options (cont)

- Total Joint Replacement/Arthrodesis
  - Advantages: Over 80% of patients have sustained relief of pain following a Total Knee Arthroplasty (TKA) and/or Total Hip Arthroplasty (THA).[39]
  - Disadvantages: BMI plays a role in decision-making, with many surgeons declining to operate on patients with a BMI greater than 40 kg/m.[2,42] Revisions are also often required.
  - Indications: Often done when pain is not responsive to conservative treatment and in patients who have functional limitations and radiographic evidence of joint degeneration.[43]
  - Overall consensus: THA and TKA surgeries are considered the gold standard treatments for end-stage knee and hip osteoarthritis respectively.[7]



Benefits of Aquatic Therapy as Prehabilitation Prior to Joint Replacement Surgery

When looking at postoperative effects of prehab prior to joint replacement:

- Aquatic Prehab (4-12 weeks)
  - Decrease in postoperative length of stay[4]
  - Improvement in HQROL[4]
  - Reduced systolic and diastolic BP[42]
  - Improved WOMAC score in all 3 subscales
    - Pain, stiffness and physical function[43]
  - Improved chair stand score[43]
  - Improved self-reported mobility[43]
  - Improved depression and cognition[43]
- Land based prehab
  - Improved pain level[28,45]
  - Improved ROM[44]
  - Improved MSK Function and performance[44]
  - Improved perceived stability of the knee during walking[45]
  - Faster self-selected and maximal walking speed[45]

Benefits of Aquatic Therapy Post Joint Replacement

Aquatic therapy after LE joint replacement has been shown to:

- Improve: WOMAC, SF-36, mean habitual gait speed, stair climbing time, stair navigation pattern, knee flexion and extension power, thigh cross sectional area, hip abductor strength, quadriceps strength, and Lequesne knee scores[7,46,47]
- Provide improvements even at 18 months post-op[46]
- Be tolerated well[46]
- Expedite and enhance knee musculature recovery (strength, power, girth)[7]
- Have significant functional improvements when activity was supervised rather than unsupervised[7]

Lee et al.[47] suggest that water therapy is good post TKA due to hydrostatic pressure principles that reduce edema as well as having reduced loading due to buoyancy forces.

Benefits of Aquatic Therapy Post Joint Replacement (cont)

However, some studies show that aquatic interventions are not significantly better than land interventions:

- In water vs land training with standardization (2x/week for 6 weeks for 60 mins, same progression and exercises), no difference was found for WOMAC scores, knee ROM, 6MWT, or stair climbing power.[7]
- No significant change was found in either land or water based treatment group for knee flexion strength or extensor strength.[48]

Benefits of Aquatic Therapy Post Joint Replacement (cont)

Timing of aquatic therapy initiation: (MD clearance required)

- Post THA: Delaying initiation of aquatic therapy to 14 days post op vs 6 yielded significantly improved WOMAC scores.[49]
  - Patients could wear waterproof adhesive bandage to protect surgical incision.[7]
- Post TKA: Early initiation of aquatic therapy at 6 days post op vs at day 14 lead to significant improvements in WOMAC, SF-36, and Lequesne knee scores at 1 year follow up, although improvements for WOMAC stiffness was insignificant.[49]

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