Aquatic Therapy for Amputees Evidence Table

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Question: In patients with lower extremity amputation, how does aquatic therapy intervention affect functional and psychosocial outcome measures compared to land-based resistance training exercise?

Search Sources: PubMed, CINAHL, SPORTDiscus,

Table I: Abbreviations Utilized in Evidence Table

Abbreviation	Full Term
RCT	Randomized control trial
QoL	Quality of life
MSK	Musculoskeletal
ADL	Activity(ies) of daily living
SF-36	Short Form-36
KOOS	Knee Injury and Osteoarthritis Outcome Score
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index
NPRS	Numeric Pain Rating Scale
TUG	Timed Up and Go
HRQL	Health Related Quality of Life
AROM	Active range of motion

PROM	Passive range of motion
ACL	Anterior Cruciate Ligament
CKC	Closed kinetic chain
ICU	Intensive Care Unit
UTT	Underwater Treadmill Training
AMP	Amputee Mobility Predictor
10MWT	10-meter Walk Test
PTSD	Post-Traumatic Stress Disorder

Table II: Evidence Table

Article	Summary of Relevant Details
Barker et al (2014)[1]	**Study Design:** Systematic Review & Meta-Analysis **Purpose:** To review and summarize the literature comparing aquatic therapy to land-based exercise and no exercise for a variety of common MSK conditions. **Included Studies:** Six (6) studies were included: 24 RCT 2 quasi-RCTs. The studies focused on individuals with osteoporosis, osteoarthritis, rheumatoid arthritis, low back pain, and fibromyalgia. **Measurements:** Three different measures were assessed: pain, physical function, and QoL. Several standardized outcome measures were utilized across he 28 studies, including the SF-36, WOMAC, and KOOS. **Outcomes:** High effect sizes were noted across MSK conditions for improvements in pain, function, and QoL in aquatic therapy conditions compared to no exercise. Moderate effect sizes were noted for a variety of (but not all) MSK conditions for pain outcomes in aquatic exercise conditions compared to land-based exercise, with smaller effect sizes noted for function and QoL outcomes for aquatic exercise compared to land based exercise. **Notes:** This is a high quality study with low risk of bias, and moderate relevance to the current capstone question. The amputee population was not considered in this paper, but it may be appropriate to generalize the data to the amputee population, given the variety of MSK conditions considered.
Bragaru et al (2011)[2]	**Study Design:** Systematic Review **Purpose:** To review and summarize literature regarding individuals with limb amputation and sport participation. The authors acknowledge that limb amputation may have negative outcomes related to physical and psychosocial wellbeing, and participation in sport often has positive effects on these areas in individuals without amputation or other neuromusculoskeletal impairments. They chose to explore the literature on the benefits of regular sport participation for individuals with amputees.

	Included Studies: Forty-seven (47) studies that focused on upper and lower limb amputation (proximal to the ankle or wrist) and sport participation were included. A variety of sports were included in the studies, as most studies either allowed for self-selected sport participation, or focused specifically on one of the following: running, swimming, sailing, golf, fishing, and "fitness". **Key Content Areas:** Five categories of outcomes emerged, including biomechanical factors and performance, cardiopulmonary function, psychological impact and quality of life, sport participation and physical function, and sports injuries. **Key Findings:** Individuals with amputation who participated in sport in some capacity demonstrated improved gait and running mechanics, cardiopulmonary function, muscle forces generated, and decreased body mass. Individuals with amputation also reported increased self-esteem, quality of life, size of social circle, acceptance of their disability, and motor skills. In some cases, physical activity and participation significantly decreased following amputation due to accessibility issues and physical constraints. While younger, unilateral transtibial amputees tended to encounter fewer barriers to participation than older, bilateral, and transfemoral amputees, a variety of activities are possible at recreational and competitive levels for individuals with amputation. **Notes:** A common theme throughout the included studies was that accessibility and awareness tended to limit sport participation for individuals with amputees. Many individuals were not aware of sport-related resources available in their community, or reported that access to these resources required significant financial resources, including sport-specific prostheses and other equipment. However, the one of the most popular sports across the studies was swimming (among cycling, golf, fishing, and "fitness") which does not require additional specialized equipment, thus keeping patient costs low. This also indicates that safety and functionality during aquatic activity may be a common goal throughout the amputee community, which can be addressed through different stages of rehabilitation.
Cutler (2017)[3] (AAO&P)	**Study Design:** Narrative Review **Purpose:** To discuss the general benefits of aquatic rehabilitation due to therapeutic, gravity-reduced conditions of the aquatic setting for transfemoral amputees.

	Subjects: Three (3) subjects were included in this paper: • Geriatric, unilateral transfemoral amputee • Young K4 unilateral transfemoral amputee • Mature adult with bilateral transfemoral traumatic amputee Information about time since amputation, level of function, and other relevant health and demographic information was not provided. **Measurements:** Ambulation time and distance, degree of muscle contraction, level of fatigue, and disability rating were assessed. Specific outcome measures were not named. **Outcomes:** All 3 participants demonstrated improved functional mobility, range of motion, levels of fatigue, and QoL based on author report. **Notes:** This is a low quality paper, with moderate to high risk of bias, given the nature of the expert opinion narrative review. However, it has the greatest relevance to the intervention and population of focus for this project.
Cutler (2017)[4] (JPO)	**Study Design:** Case Study **Purpose:** To examine the benefits of aquatic therapy combined with incorporation of skeletal capture sub-ischial transfemoral socket fitting. **Subject:** A 64-year old, 290-pound male with unilateral transfemoral amputation, 45-degree hip flexion contracture and 100-foot maximum ambulation range. These impairments were likely due to unsuccessful fit of ischial containment suction sockets over the course of 3 years, limiting his rehabilitation progress. **Measurements:** Measurements in this study included in-therapy walking time, ambulation range, hip flexion contracture, disability rating, and Tinetti fall score **Outcomes:** The subject demonstrated improved walking time from 5 to 45 minutes, ambulation range from 100 ft to 400 ft, hip flexion contracture reduction from 45-degrees to 20-degrees from baseline to 30 days into the study. At 120 days, his ambulation range increased to greater than 500 ft, hip flexion contracture reduced to 12 degrees,

	his disability rating improved form 78% to 48%, and Tinetti fall score improved from 10 to 17 (max. score 28). The patient also demonstrated a 30-pound weight loss (290 to 260 pounds), and decrease in blood pressure from 133/92 to 115/67 over the 120-day study. **Notes:** This study emphasizes the role of aquatic therapy in improving tolerance for and confidence during ambulation due to the gravity-reduced environment. The reported outcomes exceeded those anticipated through land-based therapy alone. In this paper, Cutler suggests that the patients that would benefit from aquatic therapy the most tend to be populations that are excluded from aquatic-based research studies (obese, high falls risk, delays in participation due to infection, and generally deconditioned/weak).
Heywood et al (2016)[5]	**Study Design:** Systematic Review **Purpose:** To compare the biomechanics of gait, closed kinetic chain, and plyometric exercise in the aquatic environment compared to similar, land-based interventions. **Subjects:** Twenty-eight (28) studies that focused on walking, running, stationary running, CKC, plyometric, and TUG interventions in the aquatic environment compared to land-based interventions were included. 18 of the studies specified immersion levels to chest level (xiphisternum or axilla), while the others specified waist, umbilicus, mid-thigh, or a fixed depth between 0.4-1.3 meters. **Measurements:** Studies were included if they measured spatiotemporal outcomes (speed, step length, stance time, support phase timing), kinematics (lower limb joint ROM), forces (direction and peak of vertical and anteroposterior ground reaction force, rate of force development), or muscle activation (electromyography) **Outcomes:** Very large effect sizes showed that self-selected gait speed and vertical ground reaction forces were significantly lower in the aquatic condition compared to land-based conditions. It is hypothesized that the requirement of overcoming drag force is the primary reason for slower self-selected gait speed. Maximal speed of walking and stationary running were also lower in the aquatic setting. At self-selected speed of gait, lower limb ROM and muscle activity were similar in the aquatic condition compared to on-land condition.

	Notes: Because self-selected speeds of movement may be lower in the aquatic setting, the authors suggest therapists provide specific instruction on speed of movement in order to closely approximate task specificity and optimize land-based, full weight bearing functionality.
Heywood et al (2017)[6]	**Study Design:** Systematic Review & Meta-Analysis **Purpose:** To examine the effectiveness of aquatic exercise in improving lower extremity strength in individuals with MSK conditions. **Included Studies:** Fifteen (15) RCTs focused on aquatic exercise with a resistance training component for adult subjects with MSK conditions compared with land-based exercise or no intervention were included in this review paper. **Measurements:** Lower extremity strength was measured with concentric and eccentric isokinetic testing, isometric resistance testing, and repetition maximum tests. Muscle endurance was tested via maximal repetitions or positional holds to fatigue. Power (speed and resistance) was tested via body weight vertical jump and stair climbing. Manual muscle testing was excluded due, as the other strength measures were more robust and valid. **Outcomes:** Across the included studies, the evidence suggests limited effectiveness in aquatic exercise for improving strength of hip and knee musculature for individuals with MSK conditions. **Notes:** Inconsistencies in application, inadequate dosage, and limited progressive overload of resistance training in the aquatic setting is a likely contributor to the low quality and limited data regarding this topic.
Mathis et al (2018)[7]	**Study Design:** Case Study **Purpose:** To determine the feasibility and effectiveness of an UTT program for an individual with lower limb amputation and limited ambulation potential. **Subject:** A 72-year-old male with transtibial amputation who has used a prosthesis for 2 years, and ambulates in the community with a cane. He uses a wheelchair for mobility at home. Prior to participation in this study, the patient was designated K2 status on the Medicare Functional Class K-level system.

	Measurements: To assess the patient's mobility level, walking speed, balance, and falls risk, outcome measures used included the AMP 10MWT, single leg stance and Romberg balance test, and TUG. **Outcomes:** Following 8 weeks of UTT intervention, the patient increase his K-level to K3, and all functional outcome measures were improved compared to baseline. These improvements in mobility, walking speed, balance, and falls risk were maintained at 3 months post-intervention. **Notes:** The author discussed that patients classified as K3 level or higher are eligible for coverage of higher level prosthetic devices, which would allow for continued safe functional mobility in the home environment and community.
Perkins et al (2012)[8]	**Study Design:** Literature Review **Purpose:** To review the literature for common causes of disability in the traumatic limb amputation population, and highlight interventions that optimize patient outcomes post-amputation. The authors highlight the risk of "profound and prolonged" poor health outcomes following traumatic amputation and provide several evidence-based suggestions for preventing poor outcomes in this population. **Key Content Areas:** This study focuses on common outcomes that patients experience post-amputation, and makes suggestions for interventions that can improve these outcomes. These therapies may lead to improved overall condition of health for individuals with traumatic amputation. **Key Findings:** Common outcomes among the amputee population include pain (phantom limb pain, residual limb pain, back pain, and contralateral joint pain), psychological responses (PTSD, anxiety, depression, and substance abuse) reduced physical function (gait speed, gait efficiency, energy demands of mobility, and QoL), impact on employment, and cardiovascular disease and disability. These poor outcomes have the propensity to contribute to long term morbidity and reduced QoL, but many of them can be addressed through a variety of therapeutic interventions. The author discusses pre-operative, operative, and post-operative therapies to utilize in order to improve patient outcomes. Preoperatively and operatively, measures should be taken to prevent excessive bleeding, manage pain,

	prevent infection, optimize wound healing, and reconstruct the residual limb. Post-operatively, early mobility and patient education should be emphasized in the acute phase. For long term management, pain, mental health, cardiovascular disease (particularly increased blood pressure and blood-insulin levels) must be considered. Left untreated, these outcomes may contribute to physical inactivity, increasing the risk for development of further reduced function, health, and QoL. **Notes:** While this study does not specifically discuss aquatic therapy, it provides a detailed overview of factors to consider at the different stages of care for individuals with amputation.
Severin et al (2016)[9]	**Study Design:** Literature Review **Purpose:** To summarize the current literature on aquatic activity and the effects on human movement and subsequent rehabilitation. **Key Content Areas:** This review paper discussed the physical properties of water, biomechanical benefits of exercise in the aquatic environment, these principles applied to rehabilitation of human movement, comparisons of land- versus aquatic-based exercise, and challenges associated with aquatic therapy research. **Key Findings:** The authors discuss therapeutic properties of water, such as buoyancy, hydrostatic pressure, viscosity, and thermodynamics. These properties allow individuals to experience a gravity-minimized or reduced weightbearing environment with a globally applied compressive force on the body, inherent resistive drag force to movement through the water, and potentially increased core temperature and muscle relaxation (if immersed in a body of water with temperature greater than the individual's core body temperature). The literature reports mixed data on the biomechanics of gait during under-water walking. In general, it is understood that knee and ankle motion remain consistent between aquatic and land-based walking, while hip joint motion is increased with aquatic ambulation. Joint torques may be decreased at the ankle and knee joints, with no changes at the hip joint. Additionally, the aquatic environment decreases ground reaction forces and impact forces with gait and jumping activities. Some studies of aquatic interventions have shown significant improvements in static and dynamic balance, while maximizing safety, especially for those at increased risk of falls. There is no evidence to suggest that aquatic exercise is superior to land-based exercise for the purpose of muscle strengthening, but reduced joint

	loading may allow for improved short term outcomes for a variety of rehabilitation protocols due to reduced joint loading and the previously discussed properties of water. There is a lack of conclusive evidence regarding motion tracking and specific muscle activity during aquatic activity due to limitations in equipment and funding, leaving gaps in the knowledge and therefore protocols and procedures for optimal rehabilitation.
Van Silfhout et al (2020)[10]	**Study Design:** Narrative Review **Purpose:** To suggest innovative methods of promoting early mobilization in complex patients, such as individuals with amputation, spinal cord injury, or in the ICU. **Key Content Areas:** The authors consider weightbearing status, implementation of hydrotherapy in the ICU, osseointegration for patients with lower limb amputation, and exoskeleton use in patients with spinal cord injury. **Key Findings or Suggestions:** The literature increasingly supports the benefits of early mobilization for patients with a variety of MSK, neurologic, and post-surgical impairments. Partial weightbearing allows for early mobilization and has favorable outcomes for fracture healing, maintenance of muscle strength and bone mass, and patient adherence compared to restricted or non-weightbearing status. For individuals with more complex medical and neuromusculoskeletal conditions, innovative technologies may allow for improved early mobility and therefore overall patient outcomes. Hydrotherapy, including standing, walking, upper extremity movement, and back stroke swimming, may be a safe and feasible way to mobilize critically ill patients, and reduce the magnitude and effects of ICU-acquired weakness. Osseointegration implantation after lower limb amputation may allow for earlier post-operative mobility, improved use of prosthesis, increased walking speed, and improved quality of life. Use of an exoskeleton during rehabilitation from spinal cord injury may promote neuroplasticity and increase functional mobility, postural control and balance, improve bowel and bladder function, and quality of life. **Notes:** While this review does not specifically focus on aquatic intervention and the amputee population, it provides insight into the use of innovative and adaptive technologies for early mobility and progressive rehabilitation with the ultimate goal of improving patient functional mobility and quality of life. If hydrotherapy is safe and feasible for critically ill patients, it may be so for individuals early after lower limb amputation.

Villalta et al (2013)[11]	**Study Design:** Systematic Review & Meta-Analysis **Purpose:** To investigate the effectiveness and risks of early post-operative aquatic therapy for improved functional outcomes following orthopedic surgery **Included Studies:** Eight (8) controlled trials including 287 participants, 51% of whom received aquatic therapy. All participants were < 3 months post-operative for ACL reconstruction, total hip replacement, total knee replacement, or rotator cuff repair. In each study, the control group received land-based PT intervention. Both land-based group and aquatic therapy group treatment included stretching, strengthening, ROM, and aerobic exercise. **Measurements:** The primary outcome measurement of this study was adverse events reported related to wound healing. Secondary outcomes included edema, pain, strength, ROM, activities of daily living (ADL), and QoL. Specific secondary outcome measures utilized included the KOOS, NPRS, TUG, WOMAC, AROM, PROM, and HRQL among others. **Outcomes:** Seven (7) trials reported no adverse events related to wound healing in either intervention group. One trial reported deep and superficial infections at surgical sites, with no difference between intervention and control groups. Aquatic therapy groups demonstrated significant improvements in ADL measures, and hip and shoulder AROM measures. No statistically significant differences were found between groups for measures related to pain, edema, muscle strength, or QoL. **Notes:** This study found no adverse events related to immersion of an orthopedic wound site as early as 4 days post-operative, as long as the wound was appropriately covered with a waterproof dressing that allowed for adequate limb movement. However, larger studies are needed in order to confidently determine that aquatic therapy is safe this early in post-operative care. While no statistically significant improvements were found for pain, edema, strength, and QoL, it would be reasonable to suggest that aquatic therapy is equally as effective at improving these outcomes as land-based therapy.

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