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Effectiveness of Traditional Land-Based Therapy vs Aquatic-Based Therapy after ACL Reconstruction

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By

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Introduction

The most common knee injury is a torn anterior cruciate ligament (ACL) which occurs to 1 in 3,000 people annually, making an ACL reconstruction (ACLR) surgery the sixth most common orthopedic procedure (Cohen, Yucha, Ciccotti, Goldstein, Ciccotti, & Ciccotti, 2009 Edgar, Zimmer, Kakar, Jones, Schepsis, 2008 Zamarioli., Pezolato, Mieli, Shimano. 2008). Over the past 20 years, there has been considerable growing attention to rehabilitation programs for post ACL reconstruction, but still no optimal rehabilitation program has been found. (Momberg, Louw, Crous. 2008 Zamarioli, Pezolato, Mieli, Shimano. 2008 Tovin, Wolf, Greenfield, Crouse, Woodfin. 1994). Though there have been improvements to rehabilitation protocols, there are still concepts that have limited research. A lack of comparison of traditional land-based therapy vs aquatic-based therapy is one of the main areas that is lagging in research. (Momberg, Louw, Crous 2008 Tovin, Wolf, Greenfield, Crouse, Woodfin. 1994) There should be a further evaluation of the benefits between traditional land-based therapy vs aquatic-based therapy after ACLR.

One of the component that must be understood about ACLR in order to establish an optimal rehabilitation program is graft choice and the healing process of the ligament. The rational for doing ACLR is to restore stability to the knee, maintain the range of motion and thereby minimize injury to both the chondral surfaces and the menisci (Deehan, Cawston 2005). In current surgical practices the most common grafts are either a hamstring or patellar tendon autograft. The ideal ACL graft should possess a microscopic structure and biomechanical characteristics similar to that of the native ACL and the graft should allow for early rehabilitation while protecting the anchorage points and avoiding graft slippage (Deehan, Cawston 2005). The

ACL contains four distinct histological zones: 1) ligament 2) uncalcified fibrocartilage 3) calcified fibrocartilage and 4) bone (Deehan, Cawston 2005). According to R.A. Hauser, E.E. Dolan, H.J. Phillips, A.C. Newlin, R.E. Moore and B.A. Weldin there are three consecutive phases of healing that happen over time: acute inflammatory phase, proliferation or regenerative/ repair phase, and tissue-remodeling phase. The acute inflammatory begins a few minutes after injury and continues over the next 48 to 72 hours. In this phase the blood collects around the injury site and platelet cells interact with certain matrix components, changing their shape and initiating a clot formation. The platelet-rich fibrin clot begins to release growth factors that are necessary for healing and provides a platform on which many cellular events occur. Growth factors, neutrophils, monocytes, and other immune cells migrate to the injured tissue where they ingest and remove debris and damaged cells produced during the inflammatory phase. The proliferation phase begins when immune cells release various growth factors and cytokines. The release of these enzymes initiates fibroblastic proliferation signals to rebuild the ligament tissue matrix. The tissue formed initially appears as disorganized scar tissue but over the next several weeks fibroblast cells deposit various types of collagen and enzymes into the matrix. After a few weeks the proliferation phase merges into the remodeling phase. In the remodeling phase collagen maturation starts, often lasting months or even years after the initial injury. Over time the tissue matrix starts to resemble normal ligament tissue; however, critical differences in matrix structure and functional persist.

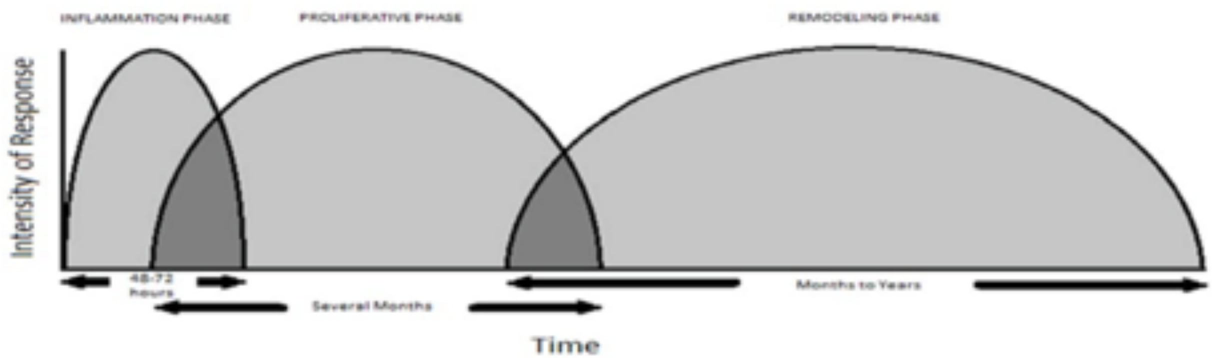

Figure 1: The intensity and approximate amount of time in the three stages of healing: inflammatory, proliferative and remodeling phases of an injured ligament. (Adapted from Cruess et al. Healing of bone, tendon, and ligament. 1975).

Deepening the research in the benefits of traditional land-based therapy vs aquatic-based therapy would be an important part in finding an optimal rehabilitation program. (Momberg, Louw, Crous 2008 Tovin, Wolf, Greenfield, Crouse, Woodfin. 1994) First, aquatic-based therapy has clear benefits, so it would behoove us to compare to find an optimal rehabilitation program for ACLR. (Geytenbeek, J. 2002. Momberg, , Louw, Crous 2008. Villalta, E.M. and Peiris, C.L. 2013. Zamarioli, A., Pezolato, A., Mieli, E., Shimano, A.C. 2008.) Second, there is limited research on the return to play difference between land-based therapy and aquatic-based therapy. (Tovin, Wolf, Greenfield, Crouse, Woodfin. 1994)

There are documented benefits of aquatic-based therapy such as; early active mobilization and improve neuromuscular performance. (Geytenbeek. 2002. Momberg, Louw, Crous 2008. Villalta and Peiris. 2013. Zamarioli, Pezolato, Mieli, Shimano. 2008.) These benefits are achieved through reducing gravitational forces on joints, water pressure reduces swelling and increases blood flow, allowing for early dynamic strengthening with hydrodynamic resistance forces. (Geytenbeek. 2002. Momberg, Louw, Crous 2008. Villalta and Peiris. 2013. Zamarioli, Pezolato, Mieli, Shimano. 2008.) Since athletes are always trying to return to their sport as soon as possible, aquatic-based therapy might be a useful form a therapy to help them achieve that goal. Although accelerated land-based programs for ACLR have been published extensively, very little research has been devoted to the combination of land and aquatic-based therapy programs for ACLR. (Tovin, Wolf, Greenfield, Crouse, Woodfin. 1994) A combined program may be beneficial to sports participants as it allows for more joint loading, aggressive rehabilitation and earlier return to function. (Geytenbeek. 2002. Momberg, Louw, Crous 2008. Villalta and Peiris. 2013. Zamarioli, Pezolato, Mieli, Shimano. 2008.)

Since ACL injuries are one of the most common orthopedic knee injuries, the purpose of the present research is to find the optimal rehabilitation programs between traditional land-based therapy and aquatic-based therapy after ACLR. (Zamarioli, Pezolato, Mieli, Shimano. 2008) Specifically this study addresses one questions: which rehabilitation protocol, traditional land-based vs aquatic-based, offers greater benefit to the athlete to return to play?

Methods

Search Strategy

A systematic search was conducted by using Google Scholar and SportsDiscuss search engines with the key phrases: “anterior cruciate ligament water”, “anterior cruciate ligament hydrotherapy”, and “anterior cruciate ligament aquatic”. The search was limited only to articles in English-language texts. Any that clearly did not fulfill the criteria were excluded. Where it was not clear, the full-text articles were obtained for detailed examination. When the full text was obtained, second-stage screening was performed independently.

Inclusion

The trials needed to be controlled trials published in a peer review journal involving adult participants (>16y old) in the early postoperative period after ACL reconstruction surgery. The trials had to compare aquatic physical therapy with land-based physical therapy. For the purpose of this review, aquatic physical therapy refers to any water-based therapy as described by Bartels et al. The exercises may include stretching, strengthening, range of motion (ROM), and aerobic exercises.

Exclusion

Articles were not included if the participants did not undergo orthopedic surgery, if rehabilitation occurred after the early postoperative period (more than 3mo postoperatively), if they included a healthy (non-matched) comparison group, if they did not compare an aquatic-based therapy group against a land-based therapy group, and if data on adverse events could not be obtained.

Studies included in this review

The initial search included six articles from Google Scholar, PubMed, and SprotsDiscuss. There were no duplicate articles found in the initial search. After eligibility of inclusion for each article was assessed, there was confirmation that there was a comparison of aquatic and land-based therapy being conducted after ACLR surgery, only two articles met the criteria. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram (Figure 2) displays the process of the final two articles (Moher, Liberati, Tetzlaff, & Altman, 2009).

PRISMA Flow Diagram

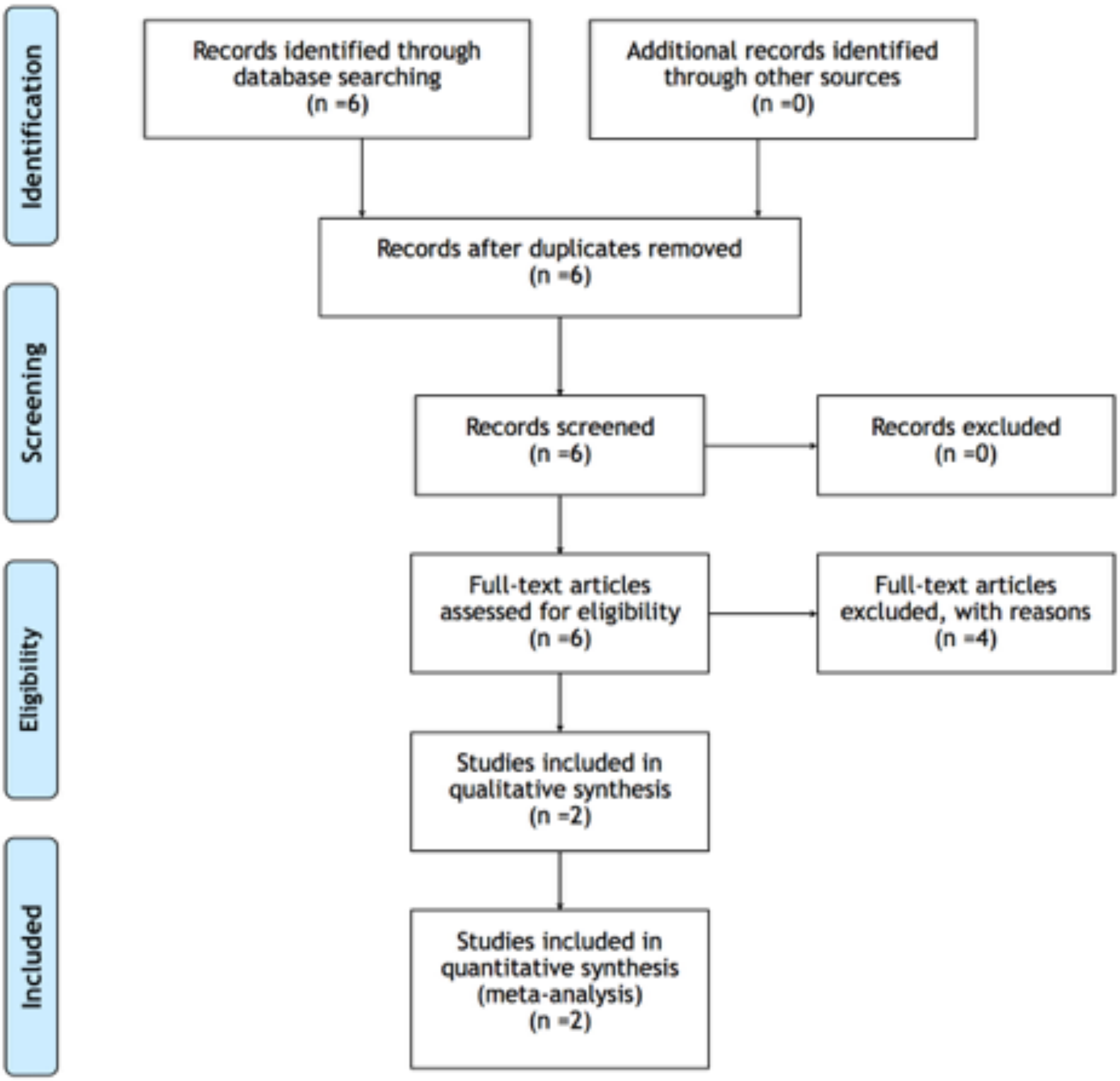

Figure 2: Flowchart of Literature Process (Moher, Liberati, Tetzlaff, & Altman, 2009).

Data Analysis

All article were reviewed for comparison of land-based therapy and aquatic-based therapy after ACLR surgery. The programs evaluated swelling (around the knee joint), range of motion (flexion and extension of the knee), strength (manual muscle tested), and pain. The results summarized the age of the participants, along with the outcome of each of permitters previously stated.

The PEDro scale was used to evaluate the internal validity and research merit of the final two journal articles (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003). The PEDro scale is a point based system ranging from 0-11 with each point received relating to specific criteria the article must meet. A score ranging from 9-10 is excellent validity, 6-8 is good validity, 4-5 is fair validity, and any score under 4 is poor validity (de Morton, 2009). The final two articles for this systematic review both had good validity.

Results

The two studies that were included in this systematic review are Tovin et al. and Zamarioli et al. These two studies were the only articles that were found in the search that compared both land-based therapy and aquatic-based therapy after ACLR surgery. The four studies the were excluded from this systematic review were excluded because they did not have a group of land-based therapy to compare to aquatic-based therapy, but had PEDro scores ranging from 6-8.

Tovin et al. did a comparison of land-based rehabilitation and strictly aquatic-based rehabilitation. In this study they had 20 subjects ranging from the ages of 16-44 y/o. All subjects underwent intra-articular ACLR surgery with a bone-tendon bone autograft, and had not previous ACL injury in either knee prior to their surgery. The subjects were informed of the different rehabilitation protocols, signed a consent form, and were randomly assigned into their groups before surgery. After the surgery both groups were instructed to do the same at home rehabilitation program twice a day for the first week. During weeks 2-8 post-op the subjects were divided into their groups of either land rehabilitation or aquatic rehabilitation. Both groups performed exercises similar to each other and completed rehabilitation three times per week. Data was collected in four major areas; which were arthrometric measurements, muscle performance measurements, passive range of motion, girth measurements, and quality of life. Arthrometric measurements were taken pre-operative and 8 weeks post-op using a KT-1000 in the position of anterior drawer with 15-lb and Lachman with 20-lb. Greater forces were not used in fear of stressing the graft too much. Muscle performance measurements were recorded for isometric and isokinetic values using an electromechanical dynamometer and LIDO AC+ software. The subjects performed three repetitions of each exercise (isometric knee flexion, isometric knee extension, isokinetic knee flexion, and isokinetic knee extension) and the maximal peak torque was recorded. Passive range of motion was taken using a goniometer at the beginning of treatment session at 2,4,6, and 8 weeks postoperatively. Lastly girth measurements of the knee were taken preoperatively and at 2,4,6, and 8 weeks postoperatively. Measurements were taken at the mid-patella and 15.54 cm above mid-patella using a standard tape measure to documents changes in knee effusion and atrophy of thigh musculature. Subjects were asked to fill out a functional questionnaire consisted a Lyscholm score on their perceived ability of certain activities at the end of the eighth week.

A few years later Zamarioli et al. did a comparison study of land-based rehabilitation and aquatic-based rehabilitation, picking up where Tovin et al. left off. Per the suggestion of Tovin et al. the aquatic-based group in Zamarioli et al. did a combination of aquatic and land during their rehabilitation. This study consisted of 13 subjects ranging from the ages of 18-55 y/o. The study was approve by the Institutional Review Board and all subjects were randomly assigned into their group. Subjects underwent rehabilitation twice a week for 50 minutes per session for nine weeks. The land-based groups performed an accelerated ACL rehabilitation program that consisted of OKC, CKC, neuromuscular training, and stretching exercises, while the aquatic-based group had a specific protocol developed with the same exercises performed as the land-based group. Clinical evaluations were performed a 0,3,6, and 9 weeks postoperatively. Measurements that were taken were pain, range of motion, strength, and circumference of knee for muscle mass and swelling. Pain was measured using a Numerical Rating Scale (NRS) ranging from zero to ten, with zero being no pain at all and ten being the worst pain. Range of motion was assessed using a goniometer. Circumference of the knee was taken using a tape measure and place 5cm above the superior margin of the patella for swelling and proximal thigh for muscle trophism. Muscle strength was assessed using manual muscle testing using a six point scale.

Discussion

The purpose of this review paper is to evaluate wether a land-based or an aquatic-based rehabilitation protocol offers greater benefit to a patient in reduction of pain, reduction of swelling, increase in range of motion, or increase in strength. This review attempted to summarize pertinent articles that included a comparison of land-based rehabilitation and aquatic-based rehabilitation after ACLR surgery.

The two articles reviewed for this paper both showed that there was no significant difference in pain reduction, knee effusion reduction, increase in strength or range of motion. While the aquatic-based rehabilitation did show greater improvement in all categories, the difference between the two groups was no significant.

Tovin et al. had a comparison group of land-based rehabilitation and a pure aquatic-based rehabilitation. There were no significant difference in the measuring of joint laxity, range of motion, swelling, isometric flexion or extension, or isokinetic extension; there was a significant difference in the mean peak torque of isokinetic flexion. The land-based group produced significantly more torque (x=96.4) then the aquatic-based group (x=81.7) with a p-value of 0.01. The authors concluded that aquatic-based rehabilitation was more effective in reducing knee effusion and facilitating recovery according to the Lysholm scores they collected. Also that aquatic-based rehabilitation was as equally effective as land-based rehabilitation for range of motion and quadricep strength, but land-based rehabilitation was more effective in increasing hamstring strength. In their conclusion they suggested that future studies should have the aquatic-based group should incorporate aquatic and land rehabilitation.

Taking the suggestion of Tovin et al., Zamarioli et al did a study where the aquatic-based rehabilitation group did both aquatic and land exercise. Comparing pain reduction, range of motion, strength, and swelling the aquatic-based group did have greater improvement then the land-based group, but there was no statistical difference between the two groups. It was reported that the aquatic-based group did have earlier neuromuscular activation which allowed for better conditions for earlier recuperation.

Though there is limited research comparing land-based and aquatic-based rehabilitation after ACLR surgery, there are other studies that we can use to compare the protocols. One of the studies is Momberg et al. where they compared three subjects with varying times of an accelerated aquatic-based rehabilitation after ACLR surgery. The subjects were assessed on pain, function, and range of motion over the course of the 12 week program. The subjects all started a land-based rehabilitation 10 days after surgery followed by a six week accelerated aquatic and land-based rehabilitation at weeks 2, 3, and 4 post surgery. After the six weeks the subjects were then withdrawn from aquatic therapy and did just land-based therapy until 12 weeks post surgery. The measurements taken were KOOS scale, six minute walk test (6MWT), and goniometry measurements and were done every week before treatment was done. The subjects had an 18-28% increase on their KOOS scale score at baseline, a 16-23% increase for subject 1 and 2 and a 57% increase for subject 3 on the 6MWT, and all subjects started with an increased range of motion during baseline and almost reached full range of motion in the aquatic phase. The study indicated that accelerated aquatic-based rehabilitation in addition to land-based rehabilitation maybe useful for people after ACLR surgery. The physical properties of water result in biological effects on the body such as decrease pain, increase range of motion, and increase coordination and early restoration of range of motion.

Kim, Kim, Kang, Lee, & Childers continued with comparing aquatic-based and land-based rehabilitation, but this time with lower extremity ligament injuries. The study consisted of 22 athletes with isolated grade I or II ligament injury in ankles or knees and were randomized into either an aquatic or land-based exercise group. Early functional rehabilitation program (ranging, strengthening, proprioceptive training, and functional exercises) was performed in both groups. All exercises were identical except for the training environment. Data were collected at baseline and at 2 and 4 weeks using a visual analog scale (VAS) for pain; static stability (overall stability index [OSI] level 5 and 3); dynamic stability (TCT), and percentage single-limb support time (%SLST). Both groups showed decreases in VAS, OSI5 and 3, and TCT, with a concomitant increase in %SLST at 2 and 4 weeks ($P < .05$). No significant differences were detected between the 2 groups in any of the outcome measures. However, the line graphs for VAS, OSI 3, TCT, and %SLST in the aquatic exercise group were steeper than those in the land-based exercise group indicating significant group by time interactions ($P < .05$). These data points indicate that the aquatic exercise group improved more rapidly than the land-based exercise group. This study concludes that people with acute ligament sprains in the lower limb, aquatic exercises may provide advantages over standard land-based therapy for rapid return to athletic activities. Consequently, aquatic exercise could be recommended for the initial phase of a rehabilitation program.

Schonewill, Rogers, Spear, Weinberg, & Pitt conducted a review of the literature to assess the effects of a combined aquatic and land-based intervention versus the traditional land-based therapy only for female soccer players in rehabilitation post anterior cruciate ligament (ACL) reconstruction. Five systematic reviews, six randomized control trials, six case-controlled studies, and one literature review were included. All data was used to assess eight ACL rehabilitation components needed to return to sport-specific activities: pain management, ROM, edema control, muscular strength, neuromuscular function, and improved gait patterns. There was evidence to support the combination of aquatic and land-based therapy as a better intervention for achieving the goals of ROM and strength, and also showed evidence of improved edema control and pain management. The study recommends adding early intervention aquatic therapy as a safe intervention for improved ROM, strength, pain control, and edema control.

There is no clear evidence that aquatic-based rehabilitation offers greater results over land-based for the early stage of rehabilitation after ACLR surgery, since both studies only covered up to nine weeks. While both articles showed that the aquatic-based groups did see greater results then the land-based group, none of the differences were statistically greater at the end of their trial period. The benefit of aquatic-based rehabilitation is that it offers earlier muscle activation and helped to facilitate better recovery than land-based rehabilitation. Fappiano and Gangaway along with Risberg, Lewek, and Synder-Mackler also suggest the benefits of aquatic therapy being increased QOL, ROM, strength, reduced pain, and edema control. The benefit of earlier muscle activation may be a more important factor as Heijne and Werner reported that earlier rehabilitation for patients after ACLR surgery reported better pain management regardless of surgical procedure.

There needs to be more studies that examine the effectiveness of land-based rehabilitation and aquatic-based rehabilitation after ACLR surgery. It would be beneficial to have future studies collect data longer than approximately nine weeks to see the difference between the two groups throughout the rehabilitation protocol, and to focus on patient perception of outcomes as a measurement. Along with the suggestion of Schonewill et. al. there needs to be more research concerning early return to sport-specific activities for patients that use aquatic intervention.

Overall there is some evidence that aquatic-based rehabilitation is an effective form of treatment in early stages rehabilitation after ACLR surgery, but is not more beneficial than land-based rehabilitation. There are still many questions that have been left unanswered that future studies could help to clarify.

Conclusion

Both land-based rehabilitation and aquatic-based rehabilitation offer the recovery of pain, range of motion, muscle strength, and swelling for an individual that has undergone reconstruction of their anterior cruciate ligament. The main benefit of aquatic-based rehabilitation is that if offers early muscle activation and helps to facilitate recovery for the individual in early stage of rehabilitation.

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Appendix

	Design	N	Outcome Measures	Duration of Study	Frequency of Measurements	Results	Data
Tovin, Wolf, Greenfield, Crouse, Woodfin. 1994	Randomized control trial	20 subjects	Arthrometric measurements, muscle performance measurements, passive range of motion, and girth measurements	8 weeks	Weeks: 2,4,6, and 8	Aquatic-based therapy was more effective in reducing effusion and facilitating recovery. Both aquatic and land-based therapy were equal in restoring ROM and quadricep strength, but land was more effective in restoring hamstring strength	Isokinetic peak torque knee flexion was statistically greater in land-based vs aquatic-based.
Zamarioli, Pezolato, Mieli, and Shimano 2008	Randomized control trial	13 Subjects	Pain, ROM, strength, effusion	9 weeks	Weeks: 0,3,6,9	No difference in the two groups between pain, ROM, strength, and effusion. Aquatic groups had earlier neuromuscular activation, which facilitated earlier recovery.	Mean pain reduction per week: Land 0.27, Water 0.46 Mean increase knee flexion ROM: Land 5.8º, Water 6.2º, knee extension ROM: Land 1.4º, Water 1.46º Mean strength increase knee flexion: Land 0.15, Water 0.25 Mean circumference: Land 0.36, Water 0.39

Table 1: Summary of the two articles comparing aquatic and land physical therapy interventions the were included in this study: design, outcome measures, frequency of assessments, and results.

	Design	PEDro Scale	N	Outcome Measures	Duration of Study	Frequency of Measurements	Results
Schonewill, Rogers, Spear, Weinberg, & Pitt 2015	Literature Review	N/A	18 articles	Pain management, ROM, edema control, muscular strength, neuromuscular function, and improved gait pattern	N/A	N/A	Evidence supported that combination of aquatic and land-based therapy as good intervention in achieving ROM, strength, edema control, and pain management.
Kim, Kim, Kang, Lee, Childers 2010	Single-blind randomized control trial	8	22 athletes	Pain (VAS), static stability (OSI 5&3), dynamic stability (TCT), and percentage single-limb time (%SLST)	4 weeks	baseline then biweekly	Aquatic group had a significantly greater VAS, OSI3, TCT, and %SLST in a group by time interaction.
Momberg, Louw, Crous 2008	Non-concurrent single subject, multiple baseline design	6	3 athletes	KOOS scale, ROM, 6MWT	10 weeks	Weekly, before treatments	A combination of aquatic and land-based rehabilitation is beneficial for patients in early phases of rehabilitation after ACLR surgery. Aquatic therapy helps reduce decrease pain, increase ROM, and neuromuscular stabilization

Table 2: Summary of the three articles of aquatic physical therapy interventions the were not included in this study: design, outcome measures, frequency of assessments, and results.