Systematic Literature Review
The Effectiveness of Aquatic Therapy Following Total Hip or Total Knee Arthroplasty: A Systematic Review

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Abstract

Background and Purpose. Joint replacement procedures are increasing. The purpose of this systematic literature review was to determine if aquatic therapy is an effective intervention post-total knee arthroplasty (TKA) and/or total hip arthroplasty (THA).

Methods. Inclusion criteria for review were: (1) TKA or THA, (2) aquatic therapy group (3) comparison group without aquatic therapy, (4) specific outcome measures, and (5) randomized controlled trials. Evidence level was determined by the Oxford Centre for Evidence-Based Medicine. Methodological rigor of each study was evaluated using the PEDro scale.

Results. Of 1,508 articles reviewed, 6 were included. Four found significant differences favoring aquatic therapy. One found no differences between aquatic and land therapy. One found no differences between specific aquatic, nonspecific aquatic, and land therapy.

Conclusion. Aquatic therapy is a viable intervention option for improving function, pain, and quality of life in individuals following TKA or THA.

Key Words: Total knee arthroplasty, Total hip arthroplasty, Aquatic therapy, Aquatics, Hydrotherapy.

Background

Osteoarthritis (OA) is the most common joint disorder in the world and the most common form of arthritis in the United States (US).[1,2] Total hip and total knee arthroplasties are orthopedic surgical procedures used to improve the function and quality of life in individuals with hip or knee OA.[3] With a steadily aging population in the US, the need for total joint replacements is expected to increase dramatically in the next 20 years. According to the Administration on Aging, approximately 20% of the population will be older than 60 by the year 2015, and approximately 25% will be older than 60 by the year 2030.[5] Between the years 2007 and 2010, a total of 915,562 total knee arthroplasties (TKA) were performed. Additionally, there were an estimated 230,000 total hip arthroplasties (THA) performed in 2007 alone.[6,7] It is estimated that by 2030, the rate of TKAs performed annually will be nearly 7 times the rate of those performed in 2005.[8]

Treatment protocols following a TKA or THA often involve physical therapy. The literature appears to indicate that post-operative complications occur more often in patients who do not exercise after their surgery.[9] Therefore, it is critical to incorporate exercise in a comprehensive rehabilitation program to avoid potential complications and hasten the recovery process. On average, patients who undergo a THA return to normal function within 4 to 5 months. Additionally, more than two-thirds of patients who undergo a TKA return to work within 3 months.[8] Interventions following joint arthroplasty frequently consist of land-based exercise as the primary mode of rehabilitation. Many of these exercises involve supine and standing strength training, gait training, and stair training.[9] This training is often combined with modalities such as electrical stimulation, heat, and/or cryotherapy.[10] However, land-based exercise and the use of modalities may not always be the optimal approach. Aquatic therapy can provide an alternative intervention for patients who may have difficulty with or cannot accomplish land-based physical therapy.

Aquatic therapy can be defined as the use of water and specifically designed activities by qualified personnel to aid in the restoration, extension, maintenance, and functional ability in persons with acute, transient, or chronic disabilities, syndromes, or diseases.[11] Water immersion has profound physiological effects that extend across of the essential homeostatic systems. These effects allow water to be used with therapeutic efficacy for a wide variety of movement disorders including musculoskeletal problems that may be associated with OA.[12]

The physical properties of water are primarily responsible for the physiological effects that occur during aquatic immersion. These physical properties include density, hydrostatic pressure, buoyancy, viscosity, and thermodynamics.[12,13] Two of the most important properties are buoyancy and hydrostatic pressure. Buoyancy is the property of a fluid to exert an upward force on a body that is wholly or partially submerged in fluid. Buoyancy allows the offloading of joints and the reduction of compressive forces. As the depth of water immersion of the body increases, the weight-bearing load on the joints of the body decreases. At 75% immersion, weight-bearing on the lower extremities is reduced by 75%.[13] This could benefit patients with a low pain tolerance for compressive forces that may be present in the early stages after a THA or TKA.

Additionally, hydrostatic pressure effects begin immediately upon immersion, causing a shift in fluid from the lower limbs to the cardiothoracic compartment. This shift in fluid often results in a reduction of lower extremity edema.[12,14] Of course, the specific hydrostatic effects on the cardiovascular system and edema are dependent on depth and patient position. Regardless, this property of water may also benefit individuals with postoperative edema associated with THA or TKA.

Edema in the involved limb is common following a TKA or THA. Lower extremity swelling after a TKA occurs primarily from the third to the fifth postoperative day.[15] Previous studies have shown that post-TKA edema is related to damage of the blood and lymph vessels and to the release of inflammatory factors. Due to both the postoperative swelling and the postoperative drainage, blood flow can be diminished. Because of this diminished blood flow, healing could be delayed from a lack of nutrients and a subsequent inability to reduce the swelling. Evidence shows that the water immersion reduces edema, increases blood flow to the joint, and reduces compressive forces. With immersion to the neck, blood flow increases to the muscles by 225% when compared to that which occurs on dry land.[12,13] These physiological effects may result in reduced pain, improved functional outcomes, and faster healing rates. The increased oxygen availability from the enhanced blood flow during immersion could also decrease the edema that may be present as part of the natural healing process.[13,14]

A recent systematic review and meta-analysis has shown that aquatic therapy is an effective intervention following orthopedic injuries and surgeries.[14] Other recent studies indicate aquatic therapy reduces pain and disability, improves overall function in older adults with OA, reduces postoperative pain, and promotes wound healing.[12,16,17] The viscous properties of water provide resistance training during immersion, which leads to increased muscular strength.[14,18,19] Following a THA or TKA, improving strength and function are important goals. Significantly decreased strength of the affected lower extremity after a TKA can remain from 3 months to a year.[10,20] In their study, Holm and colleagues (2011) found similar results in which 83% reduced knee extension strength coincided with an inhibition of the quadriceps due to swelling, ranging from 3 months to 3 years postoperatively.[21] Due to this decreased functional strength, normal gait kinematics are often altered.[20] Using the viscous properties of water as resistance, aquatic therapy can be used as a treatment intervention to increase strength in the surgically repaired limb. The physical properties of water, specifically buoyancy, can protect the joint from excessive weight-bearing while reducing edema. Gait training in an aquatic environment without the need for an assistive device may prevent patient deconditioning and improve the overall efficiency of the patient's gait.[22]

Purpose

A review of the literature found no systematic reviews pertaining to aquatic therapy and its potential benefits for rehabilitation following a TKA or THA. One systematic review by Villalta and Peiris reported the benefits of aquatic therapy following orthopedic surgeries. However, this review addressed multiple orthopedic surgeries, not just total joint replacements.[14] One important finding of this review was that aquatic therapy did not produce wound-related adverse events. However, more information regarding outcomes of aquatic therapy after hip and knee arthroplasty is needed. Therefore, the purpose of this systematic review was to determine if aquatic therapy is an effective intervention for patients post-TKA and/or THA.

Methods

Databases and Search Terms

The databases that were searched included CINAHL Plus with Full Text, ProQuest Medical Library, and SPORTDiscus with Full Text. The search terms used were "aquatics" or "aquatic therapy" or "pool therapy" or "hydrotherapy" and "total knee arthroplasty" or "total knee replacement" or "TKA" or "total hip arthroplasty" or "total hip replacement " or "THA" and "randomized." A search of the Cochrane Library revealed no systematic reviews investigating the effects of aquatic therapy on patients who have had a TKA and THA. There were no date or age restrictions on the search. Only studies written in English were reviewed, potentially introducing a language bias.

Inclusion and Exclusion Criteria

The inclusion criteria for this systematic review were as follows: (1) patients who have had a TKA or THA, (2) an intervention group who participated in aquatic therapy, (3) a comparison group who did not participate in aquatic therapy, (4) outcome measures that included pain, functional status, and/or quality of life, and (5) randomized controlled studies.

The exclusion criteria for this systematic review were as follows: (1) patients who have had an orthopedic surgery other than a TKA or THA, (2) outcome measures other than those listed in the inclusion criteria, and (3) studies other than randomized controlled studies.

Evidence Level

Evidence level was determined by the *Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence.*[23] Level 1 consists of systematic reviews of randomized controlled trials, or "n-of-1" trials. An n-of 1 is a trial in which random allocation can be used to determine the order in which an experimental and a control intervention are given to a patient. Level 2 consists of randomized trials or observational studies with dramatic effect. Level 3 includes non-randomized controlled cohorts of follow-up studies. Level 4 includes case-series, case control studies, or historically controlled studies. Level 5 consists of mechanism-based reasoning. Level 1 is considered to be the highest level of evidence and level 5 is considered to be the lowest. To reduce the risk of bias, all 5 authors independently evaluated the articles. Scales used for article evaluation included the *Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence* and the PEDro scale.[23,24] If differences of opinion existed, a consensus was reached upon discussion between the authors.

Methodological Rigor

The methodological rigor of each included study was evaluated using the PEDro scale.[24] There are 11 items on the scale and points are awarded when a criterion is clearly satisfied. However, the first item of the PEDro scale refers to external validity, which is not included in the total PEDro score. Therefore, a 10-point PEDro scale is used. The 10 items are as follows: (1) Subjects were randomly allocated to groups; (2) allocation was concealed; (3) the groups were similar at baseline regarding the most important prognostic indicators; (4) there was blinding of all subjects; (5) there was blinding of all therapists who administered the therapy; (6) there was blinding of all assessors who measured at least 1 key outcome; (7) measures of at least 1 key outcome were obtained from more than 85% of the subjects initially allocated to groups; (8) all subjects for whom outcome measures were available received the treatment or control condition as allocated, or, where this was not the case, data for at least 1 key outcome was analyzed by intention to treat; (9) the results of between-group statistical comparisons are reported for at least 1 key outcome; (10) the study provides both point measures and measures of variability for at least 1 key outcome. The items are given 1 point for each "yes" and 0 points for each "no" answer. The articles were independently evaluated by all 5 authors to decrease the risk of bias. If differences of opinion existed, a consensus was reached upon discussion between the authors.

Results of Data Extraction and Analysis

Search Strategy

Through a database search, a total of 1,503 articles were identified. Three articles were identified using other sources. After the removal of duplicates and the screening of records as shown by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2009 flow diagram (Figure 1), all but 12 studies were eliminated. These 12 articles were assessed for eligibility based upon their full text. Six studies were excluded, as they did not meet the inclusion criteria, and the remaining 6 studies[25-30] were included in the qualitative analysis.

Evidence Level

All 6[25-30] studies were randomized controlled trials and were classified as level 2 evidence (Table 1).

Methodological Rigor

One study[26] included in this systematic review was considered to have a methodological rigor of 8/10. The remaining 5 studies[25,27-30] were considered to have a methodological rigor of 7/10 (Table 2).

In all of the studies,[25-30] subjects were randomly allocated to groups. In 5 of the 6 studies,[26-30] allocation was concealed. One of the 2 studies by Giaquinto et al[25] did not specifically report a concealing of allocation. In 5 of the 6 studies,[25-27,29,30] the groups were not similar at baseline regarding the most important prognostic indicators. The McAvoy study[28] reported significant differences at baseline between the 2 groups of participants with regards to pain, activities of daily living, and quality of life measurements. No studies in this systematic review provided blinding of all subjects or blinding of all therapists who administered the therapy. In 3 of the 6 studies,[25,26,28] there was blinding of all assessors who measured at least 1 key outcome. Harmer et al[27] occasionally allowed blinding to be revealed due to assessor absence. Rahman et al[29] did not mention a blinding of assessors. Valtonen et al[30] only performed 1 of the measurements using a blinded assessor. In all 6 studies,[25-30] measures of at least 1 key outcome were obtained from more than 85% of the subjects initially allocated to groups. All subjects for whom outcome measures were available received the treatment or control condition as allocated. Where this was not the case, data for at least 1 key outcome was analyzed by "intention to treat." The results of the between-group statistical comparisons were reported for at least 1 key outcome. Finally, the study provided both point measures and measures of variability for at least 1 key outcome.

Outcome Measures

Important and clinically relevant measures to consider after joint replacement, regardless of the therapy provided, are pain, function, and quality of life.[3,31] The 4 pain-related outcome measures used to determine effectiveness of aquatic

Table 1. Evidence Level (EL) Results, Based on Oxford Level of Evidence[23]

Study	Hierarchy	EL
Giaquinto et al (2010a)[25]	Randomized controlled trial	2
Giaquinto et al (2010b)[26]	Randomized controlled trial	2
Harmer et al (2009)[27]	Randomized controlled trial	2
McAvoy (2009)[28]	Randomized controlled trial	2
Rahmann et al (2009)[29]	Randomized controlled trial	2
Valtonen et al (2010)[30]	Randomized controlled trial	2

Table 2. Methodological Rigor (MR) Results, Based on PEDro Scale[24]

Study	1[a]	2	3	4	5	6	7	8	9	10	MR
Giaquinto et al (2010a)[25]	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Giaquinto et al (2010b)[26]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Harmer et al (2009)[27]	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
McAvoy (2009)[28]	Y	Y	N	N	N	Y	Y	Y	Y	Y	7
Rahmann et al (2009)[29]	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Valtonen et al (2010)[30]	Y	Y	Y	N	N	N	Y	Y	Y	Y	7

[a](1) Subjects were randomly allocated to groups, (2) allocation was concealed, (3) the groups were similar at baseline regarding the most important prognostic indicators, (4) there was blinding of all subjects, (5) there was blinding of all therapists who administered the therapy, (6) there was blinding of all assessors who measured at least 1 key outcome, (7) measures of at least 1 key outcome were obtained from more than 85% of the subjects initially allocated to groups, (8) all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least 1 key outcome was analyzed by "intention to treat," (9) the results of the between-group statistical comparisons are reported for at least 1 key outcome, (10) the study provides both point measures and measures of variability for at least 1 key outcome.

therapy for TKA and THA in the studies included in this systematic review were the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the Knee Injury and Osteoarthritis Outcome Score (KOOS), the Visual Analog Scale (VAS), and the Numeric Pain Rating Scale (NPRS). The most commonly used outcome measure was the WOMAC, which was included in 5 of the 6 studies.[25-27,29,30] The WOMAC is a 41-item self-report questionnaire with 5 dimensions, including pain, stiffness, physical function, social function, and emotional function.[32] The pain dimension of the WOMAC consists of 5 items, and responses are based on a 5-point Likert-type scale. Scores range from 0 to 20, with a higher score indicating increased impairment. The WOMAC is known to be a reliable and valid multidimensional outcome measure designed specifically for patients with OA of the hip or knee.[32] An extension of the WOMAC is the KOOS, an outcome measure aimed at younger, more active patients who are experiencing osteoarthritic knee pain.[33] The KOOS is a 42-item self-report questionnaire with 5 dimensions, including pain, other disease-specific symptoms, activities of daily living function, sport and recreation function, and knee-related quality of life. The pain dimension of the KOOS contains 9 items. Each item is scored on a scale of 0 to 4. The sum of the 5 dimensions is then transformed to a 0 to 100 scale, with 0 representing the most severe knee problems. The KOOS has good test-retest reliability, content validity, and construct validity.[34] Two other pain-related outcome measures were used in the studies included in this systematic review. One of these outcome measures was the VAS.[35] The VAS is administered by having the patient make a mark on a 10-centimeter (cm) line. Selections range from 0 cm (no pain at all) to 10 cm (worst imaginable pain). The VAS has good test-retest reliability ($r = .94$) for literate patients but decreased test-retest reliability ($r = .71$) for illiterate patients.[35] The other pain-related outcome measure was the NPRS.[36,37] The NPRS is an 11-point verbally reported scale ranging from 0 (no pain) to 10 (worst pain imaginable). The NPRS is reported to have a test-retest reliability of r = .78 when applied to a geriatric population.[36] Other studies indicate the NPRS has adequate test-retest reliability when administered 1 week apart (r = .63), but the test-retest reliability increases with increasing numbers of ratings, with the highest reliability for 4 ratings per day taken after 7 days (r = .95).[37]

The 10 functional outcome measures used in this systematic review were the WOMAC, the KOOS, the Patient Specific Functional Scale (PSFS), the Timed Up and Go (TUG), the 6-minute walk test, the 10-meter walk test, stair climbing power, ascending stairs, maximal walking speed, and habitual walking speed. The functional portion of the WOMAC evaluates the self-perceived functional status of patients.[32] The questionnaire consists of 17 items specific to function, and responses are based on a 5-point scale. Scores for function range from 0 to 68, with higher scores corresponding to a higher impairment.

The WOMAC is considered to be the gold standard for the assessment of self-perceived functional status in patients with OA and total joint arthroplasty. The KOOS is also used to evaluate self-perceived functional status.[33] The KOOS consists of 5 subscales: pain, other symptoms, function in activities of daily living, function in sport and recreation (sport/rec), and knee-related quality of life. Standardized answer options are given and each question is assigned a score from 0 to 4. The ADL function dimension contains 17 items. All of the items are scored on a 0 to 4 scale, with a lower score indicating worse functional ability.

The PSFS is administered by having the patient identify up to 5 important activities that they are having difficulty perfoming.[38] They are then asked to rate the activity on an 11-point scale. The level of difficulty associated with each activity ranges from 0 (unable to perform activity) to 10 (able to perform activity at same level as before injury or problem). Not only is construct validity confirmed with this outcome measure, but the test-retest reliability is also excellent.[38]

During the TUG, the patient is required to rise from a standard arm chair, walk safely and comfortably to a mark 3 meters away, and return to the same chair.[39] This test has an intraclass correlation coefficient of .75.[39]

The 6-minute walk test is administered on a 46-meter flat rectangular surface. Patients are encouraged to cover as much distance as possible in 6 minutes and are allowed to use assistive devices as needed. This test has an intraclass correlation coefficient of .94.[39]

During the 10-meter walk test, walking speed is measured over 10 meters using a stopwatch.[40,41] Mobility aids are used if required, provided no physical assistance is needed from another person.[40]

Stair climbing power is defined as force multiplied by velocity.[4] This test has excellent test-retest reliability (r = .99).[42] In the study by Valtonen, ascending stairs was used as a functional outcome measure.[30] Each patient twice ascended 10 steps, with a 1-minute rest between trials, and the fastest trial was recorded as the score. A handrail or a step-to gait pattern was used only if needed. This measure was shown to have an intraclass correlation coefficient of .73 for the persons tested with total knee replacements.[30]

The outcome measures of walking speed and habitual walking speed were also used in the Valtonen study.[30] The patients performed 2 trials of maximal speed walking and habitual speed walking with a 1-minute break between trials. The fastest trial was recorded as the score. The intraclass correlation coefficient for maximal walking speed for patients with a total knee replacement was found to be .86, and for habitual walking speed for patients with a total knee replacement, .44.[30]

Finally, the KOOS was the only quality of life measure used in the studies included in this review. The knee-related quality of life dimensions of the KOOS contain 4 items that are scored on a scale from 0 to 4. There is a maximum score of 16 for this dimension, with a lower score indicating a worse knee-related quality of life.[33]

Summary of Studies

In the study by Giaquinto et al, 31 subjects were randomly assigned to an aquatic therapy group (group 1) and 33 subjects were randomly assigned to a land therapy group (group 2) following THA.[25] Group 1 participated in 20 minutes of passive joint motion followed by 40 minutes of aquatic therapy activities. Group 2 participated in 40 minutes of land therapy activities followed by 20 minutes of hip scar massage. Both groups participated in therapy 6 times per week for 3 weeks. The outcome measure of interest in this study was the WOMAC. The WOMAC was administered at discharge and 6 months after discharge. There were no dropouts noted at either of these reevaluations. The outcomes related to this study are outlined in Table 3.

In the Giaquinto et al study, 28 subjects were randomly assigned to an aquatic therapy group (group 1) and 30 subjects were randomly assigned to a land therapy group (group 2) following TKA.[26] Group 1 participated in 20 minutes of passive joint motion followed by 40 minutes of aquatic therapy activities. Group 2 participated in 40 minutes of land therapy activities followed by 20 minutes of hip scar massage. Both groups participate in therapy 6 times per week for 3 weeks. The outcome measure of interest in this study was the WOMAC. The WOMAC was administered at discharge and 6 months after discharge. There were no dropouts noted at either of these reevaluations. The outcomes related to this study are outlined in Table 3.

Table 3. Summary of Studies

Author and Date	EL and MR[a]	Population	Interventions	Outcomes
Giaquinto et al (2010a)[25]	EL = 2 MR = 7	Group 1 = 31 Group 2 = 33	Aquatic therapy Land therapy	Pain: • WOMAC: 45.6% of group 1 and 23.0% of group 2 reported no pain 6 months after discharge; group 1 reported significantly less pain than group 2 at discharge ($P < .01$) and 6 months after discharge ($P < .01$). Function: • WOMAC: 19.3% of group 1 and 2.6% of group 2 reported no functional problems 6 months after discharge; group 1 reported significantly less functional problems than group 2 at discharge ($P < .01$) and 6 months after discharge ($P < .01$).
Giaquinto et al (2010b)[26]	EL = 2 MR = 8	Group 1 = 28 Group 2 = 30	Aquatic therapy Land therapy	Pain: • WOMAC: 57.1% of group 1 and 16.7% of group 2 reported no pain 6 months after discharge; group 1 reported significantly less pain than group 2 at discharge ($P < .01$) and 6 months after discharge ($P < .01$). Function: • WOMAC: 21.4% of group 1 and 0% of group 2 reported no functional problems 6 months after discharge; group 1 reported significantly less functional problems than group 2 at discharge ($P < .01$) and 6 months after discharge ($P < .01$).
Harmer et al (2009)[27]	EL = 2 MR = 7	Group 1 = 53 Group 2 = 49	Aquatic therapy Land therapy	Pain: WOMAC: There was no significant difference between group 1 and group 2 during the 8-week or 26-week follow-up. VAS: There was no significant difference between groups during the 8-week or 26-week follow-up. Function: WOMAC: There was no significant difference between groups during the 8-week follow-up; group 1 reported significantly less functional problems than group 2 during the 26-week follow-up ($P = .04$). 6-minute walk test: There was no significant difference between groups during the 8-week or 26-week follow-up. Stair climbing power: There was no significant difference between groups during the 8-week follow-up; group 1 demonstrated significantly less functional problems than group 2 during the 26-week follow-up ($P = .005$).

Author and Date	EL and MR[a]	Population	Interventions	Outcomes
McAvoy (2009)[28]	EL = 2 MR = 7	Group 1 = 15 Group 2 = 15	Integrated therapy (aquatic + land) Land therapy	Pain: KOOS: There was no significant difference between groups at discharge (P = .35) or 6 months after discharge (P = .30). NPRS: There was no significant difference between groups at discharge (P = .68). Function: KOOS: There was no significant difference between groups at discharge (P = .12) or 6 months after discharge (P = .42). Quality of life: KOOS: There was no significant difference between groups at discharge (P = .13) or 6 months after discharge (P = .40).
Valtonen et al (2010)[30]	EL = 2 MR = 7	Group 1 = 26 Group 2 = 24	Aquatic therapy No intervention	Pain: WOMAC: There was no significant difference between groups (P = .352) at discharge. Function: WOMAC: There was no significant difference between groups (P = .212) at discharge. Maximal walking speed: There was no significant difference between groups (P = .532) at discharge. Habitual walking speed: Group 1 demonstrated significantly less functional problems than group 2 (P = .005) at discharge. Ascending stairs: Group 1 demonstrated significantly less functional problems than group 2 (P = .006) at discharge.

[a]EL: Evidence level; MR: Methodological rigor.

In the Harmer et al study, 53 subjects were randomly assigned to an aquatic therapy group (group 1) and 49 subjects were randomly assigned to land therapy group (group 2) following a TKA. Group 1 participated in 1 hour of aquatic therapy activities, which included 5-minute warm-up and cool-down periods. Group 2 participated in 1 hour of land therapy activities, which included 5-minute warm-up and cool-down periods. Both groups participated in therapy 2 times per week for 6 weeks. The outcome measures of interest in this study were the WOMAC, the VAS, the 6-minute walk test, and stair climbing power. Using these outcome measures, the subjects were reevaluated at an 8-week follow-up and a 26-week follow up. At the 8-week follow-up, 50 subjects from group 1 and 49 subjects from group 2 were reevaluated. The outcomes related to this study are outlined in Table 3.

In the McAvoy study, 15 subjects were randomly assigned to an integrated aquatic therapy and land therapy group (group 1) and 15 subjects were randomly assigned to a land therapy group (group 2) following TKA. Group 1 participated in 30 minutes of aquatic therapy activities followed by 30 minutes of land therapy activities. Group 2 participated in 60 minutes of land therapy activities. Both groups participated in therapy 2 times per week for 6 weeks. The outcome measure in this study was the KOOS. The KOOS was administered at discharge and 6 months after discharge. There were no dropouts noted at either of these reevaluations. The outcomes related to this study are outlined in Table 3.

In the Rahmann et al study, 18 subjects were randomly assigned to a specific aquatic therapy group (group 1), 19 subjects were randomly assigned to a nonspecific aquatic therapy group (group 2), and 17 subjects were randomly assigned to a land therapy group (group 3) following either a THA or TKA.[29] All of the subjects received 1 land therapy treatment each day. In addition, group 1 participated in up to 40 minutes of supervised aquatic therapy activities, group 2 participated in up to 40 minutes of unsupervised aquatic therapy activities, and group 3 participated in up to 40 extra minutes of land therapy activities. All 3 groups participated in therapy 7 times per week for 2 weeks. The outcome measures of interest in this study were the WOMAC, the 10-meter walk test, the TUG, and the PSFS. Using these outcome measures, the subjects were reevaluated at a 14-day follow-up, a 90-day follow-up, and 180-day follow-up. At the 14-day follow-up, 17 subjects from group 1, 19 subjects from group 2, and 17 subjects from group 3 were reevaluated. At the 180-day follow-up, 14 subjects from group 1, 17 subjects from group 2, and 17 subjects from group 3 were reevaluated. The outcomes related to this study are outlined in Table 3.

In the Valtonen et al study, 26 subjects were randomly assigned to an aquatic therapy group (group 1) and 50 subjects were randomly assigned to a control group (group 2) following a TKA.[30] Group 1 participated in therapy 2 times per week for 12 weeks. Each therapy session consisted of an 8-minute warm-up, 30 to 40 minutes of aquatic therapy activities, and a 5-minute cool-down. Group 2 received no intervention. The outcome measures of interest in this study were the WOMAC, maximal walking speed, habitual walking speed, and ascending stairs. Using these outcome measures, the subjects were reevaluated at discharge. At discharge, 25 subjects from group 1 and 21 subjects from group 2 were reevaluated. The outcomes related to this study are outlined in Table 3.

Discussion

The purpose of this systematic review was to determine if aquatic therapy is an effective intervention for patients post-TKA and/or THA. Six studies[25-30] were included in the qualitative synthesis.

The outcome measures used in the systematic review were those associated with pain, function, and quality of life. Based on the outcomes in Table 3,[25-27,30] of the 6 studies, 4 found several statistically significant differences in favor of aquatic therapy. One[28] of the 6 studies found no significant differences between aquatic therapy and land therapy. The remaining study[29] found no significant differences between specific aquatic therapy, nonspecific aquatic therapy, and land therapy. Based upon these results, aquatic therapy produced superior, or at least equivalent outcomes when compared to land therapy or no intervention. Therefore, the evidence suggests aquatic therapy may be used as an effective alternative or integrated form of intervention for patients who have experienced a THA or TKA.

Both Giaquinto studies[25,26] found that aquatic therapy demonstrated statistically significant improvements in pain and function when compared to land therapy. Because the WOMAC was used in both studies, the potential benefits of aquatic therapy could be due to the overall effects of the water on the human body. Nearly all the biological effects of immersion are related to the fundamental principles of hydrodynamics. Water immersion has profound effects that extend across all of the essential homeostatic systems due to its unique properties, which include viscosity, buoyancy, hydrostatic pressure, and thermodynamics. These effects allow water to be used with therapeutic efficacy for a large variety of movement disorders, including the musculoskeletal problems that may be associated with TKA and THA.[12]

Harmer et al[27] found that aquatic therapy demonstrated statistically significant improvements in 2 functional outcome measures, the WOMAC and stair climbing power, when compared to land therapy at the 26-week follow-up. However, these improvements were not apparent at the 9-week follow-up. Harmer at al[27] stated that "the lesser improvement beyond 8 weeks in [stair climbing power] in the land-based group may be attributable to functional limitations secondary to cardiac disease which was more frequent in this group."[27]

McAvoy et al[28] found no statistically significant differences between integrated therapy (aquatic therapy + land therapy) and land therapy alone. This finding is especially important for those patients who have a limited ability to initiate and/or participate in land-based therapy due to weight-bearing tolerance, pain, stiffness, balance, or fear of falling. In these cases, patients who chose to add aquatic therapy to their land-based exercise regime may be relatively assured that their outcomes measures should not decrease.

Rahmann et al[29] found no statistically significant differences between specific aquatic therapy, nonspecific aquatic therapy, and land therapy. Again, this finding is especially important for those patients who have a limited ability to initiate and/or participate in land-based therapy, providing evidence that aquatic therapy is another option. In addition, this finding further demonstrates the potential healing effects of water immersion, as even the nonspecific aquatic therapy group demonstrated improvements in patient outcomes, including strength, gait speed, and functional ability at day 14 after surgery. It has been found that the hydrostatic effects of water are able to improve dependent edema, improve subjective pain reports, increase perceived well-being, and reduce anxiety in patients.[12] Therefore, in terms of patients with severe edema, increased pain, or anxiety, aquatic therapy may be utilized to reduce their fears and improve their functional outcomes.

Valtonen et al[30] found that aquatic therapy demonstrated statistically significant improvement at discharge in habitual walking speed and ascending stairs when compared to the group that received no intervention. In this study, the patients began their therapy 4 to 18 months postoperatively. Therefore, improvement could have already occurred naturally without intervention. Aquatic therapy is often delayed for fear of infection or increased risk of wound-related adverse events. However, a recent meta-analysis by Villalta et al determined that early aquatic therapy does not increase these risks following an orthopedic surgery, including a THA or TKA.[14] The surgical incision may be protected by applying the proper wound occlusive, waterproof dressings.

Strengths and Limitations

The primary strengths of this systematic review are: (1) no similar systematic reviews were discovered in the Cochrane Library, (2) all of the included studies[25-30] were randomized controlled trials and were therefore classified as level 2 evidence, (3) all of the included studies[25-30] had a methodological rigor of 7 or 8 on the PEDro scale, and (4) the risk of bias was minimized because all 5 authors participated in the evidence level and methodological rigor processes. The primary limitations of this systematic review were: (1) only 6 randomized controlled trials were included in the qualitative synthesis, and (2) the database search was limited to English, potentially introducing a language bias.

Implications for Clinical Practice and Future Research

Evidence from the studies in this systematic review indicate that aquatic therapy may be used as an effective alternative or integrated form of intervention for patients who have experienced a THA or TKA. This finding is especially important for those patients who have a limited ability to initiate and/or participate in land-based therapy due to weigh-bearing tolerance, pain, stiffness, balance, or fear of falling. All of the studies found that aquatic therapy produced either superior, or at least equivalent outcomes when compared to land therapy or no intervention.

Future research should assess how the frequency, intensity, and duration of aquatic therapy may affect patient outcomes. Although a previous study[28] examined aquatic therapy in conjunction with land therapy during the same day, an integrated approach of alternating aquatic-based and land-based visits within the same week would be interesting to investigate. It would also be beneficial to examine aquatic therapy, land therapy, and integrated therapy as separate entities in the same study, comparing between-group and within-group effects to determine which approach is the most effective. Examining the effects of the amount of weight-bearing provided during gait in an aquatic environment on patient outcomes could provide further insight into the proper therapeutic progression in an aquatic environment. Finally, it would be beneficial to discern the most appropriate time to initiate aquatic therapy following total hip or total knee arthroplasty.

Conclusion

This systematic review of literature indicates that aquatic therapy provides an important alternative therapeutic intervention for individuals with THA or TKA who have difficulty with land-based therapy or for who land-based therapy is not appropriate. In all of the included studies,[25-30] the aquatic therapy group demonstrated comparable or statistically significant gains in the areas of pain, function, and quality of life. These findings were consistent at short-term and long-term reevaluations, signifying that aquatic therapy is an effective treatment option. Therefore, this systematic review indicates that aquatic therapy should be considered a viable therapy alternative for those individuals who undergo TKA or THA surgical procedures.

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