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Aquatic vs. Land-Based Exercises as a Viable Treatment for Knee Osteoarthritis

Kelsey Kallioinen
Pacific University

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Title: Aquatic vs. Land-Based Exercises as a Viable Treatment for Knee Osteoarthritis

Clinical Scenario: The patient who indirectly led me to pursue this question was a 62 year-old male with a diagnosis of cauda equina syndrome secondary to excess inflammation after a lumbar spine decompression surgery. Medical treatment to date has included nine months of aquatic and land-based physical therapy. Problems identified include weak and insensate bilateral lower extremities, notably weak hip and knee extensors, plantarflexors, dorsiflexors and hip abductors. This patient led me to seek out the efficacy of aquatic therapy, however the research is lacking in studies concerning cauda equina syndrome and aquatic therapy, as the condition is rare. As this clinic has the only pool in town, and many patients are referred here specifically for aquatic treatment, I was interested in what the research has to say about aquatic therapy. Knee osteoarthritis(OA) was the most commonly occurring diagnosis with randomized control trials, so I decided to seek out what the literature reports for such patients.

Brief introduction: For the purposes of my clinical question, I want to know what has been reported in the literature about the effect of aquatic therapy as compared to land-based exercises on patients with OA of the knee. The patients in the outpatient clinic I am working tend to live independent, active lives with a high need to be able to ambulate for activities of daily living and in the community. Furthermore, with the winters here in Fairbanks, Alaska, there is also a need to be able to navigate and tolerate uneven and slippery surfaces safely, in very cold weather. As this is the only clinic with a pool in town, I was interested to see if there is a difference between treatment on land or in the pool with regard to affecting the level of pain, strength and disability in these patients.

My Clinical question: Is aquatic therapy more effective than land-based exercises at affecting the pain, strength and mobility deficits associated with knee osteoarthritis?

Clinical Question PICO:
>   **Population** – Adults with chronic primary knee OA
>   **Intervention** - Aquatic exercises
>   **Comparison** - Land-based exercises
>   **Outcome** - Pain level, LE strength and function levels

Overall Clinical Bottom Line: Based on the results of the outcomes from Lund *et al.* (6) and Wang *et al.* (13) aquatic therapy has not been shown to be more or less effective than land-based exercises at affecting the pain, strength and mobility deficits in patients with primary knee OA. Overall, these two high-quality studies provided limited evidence to suggest that either type of therapy may be beneficial compared to a control group receiving no additional exercise training. The evidence is limited due to inconsistent results and small amounts of significant differences between groups.

Three months after treatment completion, Lund *et al.* reported a small decrease in knee flexor and extensor strength between the aquatic and control groups, a small decrease in resting pain level between the land-based and control groups and a small increase in knee flexor and extensor strength between the land-based and control groups. The study by Lund *et*

al. also reported fewer subjects than desired to achieve an adequate power attributed to results. This was the only major threat to internal validity between the studies. Immediately after treatment completion, Wang *et al.* reported that KOOS ADL scores, 6MWT distances and knee extension measurements for both exercising groups were significantly different and improved compared to the control group. Although pain level was not shown to be statistically different from the control group, a clinically significant decrease in pain level was demonstrated within both exercise groups. Despite limited significance, these contradicting results suggest that if either therapy is effective at addressing impairments associated with knee OA, they are likely similarly effective compared to no therapy. As it has been shown that exercise has a wide range of benefits for patients with knee OA, these studies may suggest, or at least not deny, an encouraged use of aquatic therapy for appropriate patients, if available, to compliment land-based exercises.

Results are difficult to generalize to the population due to the amount of exclusionary criteria for subjects allowed into these studies. Most patients have more complicated medical histories or have tried previous treatment. Furthermore, the subjects in the study by Wang *et al.* were community dwelling adults being treated in exercise class situations. As they likely represent the greater population, their functional level is also likely higher than a majority of patients seen in clinics. While the clinical effectiveness of an aquatic or land-based exercise class for addressing pain, function and knee extension for patients with knee OA is not clear, the financial and time costs of treatment appear to be consistent with methods commonly available and the protocols employed would be readily applied in a clinical setting.

The literature is not lacking high-quality randomized controlled studies (RCTs) on this topic; however the methods employed are consistently inconsistent. Further research is necessary to adequately answer this clinical question, specifically more controlled studies to address the length and timeframe of a successful program, the type of exercises, increased power of the statistics with more subjects, and more studies with control groups to minimize outside factors from skewing results.

Search Terms: aquatic exercise, aquatic therapy, osteoarthritis, hydrotherapy,

Appraised By: Kelsey Kallioinen, SPT
                School of Physical Therapy
                College of Health Professions
                Pacific University
                Hillsboro, OR 97123
                kelsey@pacificu.edu

Rationale for chosen articles: To begin the search process, I looked extensively for articles having to do with aquatic therapy and cauda equina syndrome, with no results. The common diagnosis that the aquatic therapy literature represented by PubMed was overwhelmingly OA, so my initial PICO was altered. In narrowing my search for aquatic exercises and OA, the resulting articles focus on patients with OA in their weight-bearing joints, either hips or knees, and were divided in studying the effect of aquatic therapy after total-joint surgery or on OA specifically. I chose to compare land-based exercise to aquatic exercise with a focus on pre-surgery patients with OA to see which type of therapy may delay the need to replace joints. I chose these three articles because they consistently showed up in searches on PubMed, Medline-Ovid, and CINAHL databases, they had high scores of 7-8/10 on PEDro and were in a recent systematic review on the topic. (1) After reading the six article abstracts that fulfilled these criteria, or were published after the systematic review, I chose these three because they had a control group to better determine treatment effects for each type of therapy.

1. Lund H, Weile U, Christensen R, Rostock B, Downey A, Bartels EM, Danneskiold-Samsoe B, Bliddal H. A randomized controlled trial of aquatic and land-based exercise in patients with knee osteoarthritis. *Journal of Rehabilitation Medicine* 2008; 40(2):137-144.

> PEDro Score: 8/10
> Patient: Included 71 patients who were similar to my patient
> Intervention:
> - Aquatic exercise program
> - Land-based exercise program
> - Control group, no additional exercise
>
> Outcome measures:
> - Pain via Visual Analog Scale (VAS)
> - Knee Injury and Osteoarthritis Outcome Score (KOOS)
> - Standing Balance via Balance Master Pro®
> - Quadriceps and hamstring strength via dynamometry

2. Foley A, Halbert J, Hewitt T, Crotty M. Does hydrotherapy improve strength and physical function in patients with osteoarthritis-a randomised controlled trial comparing a gym based and a hydrotherapy based strengthening programme. *Annals of the Rheumatic Diseases* 2003; 62(12):1162-1167.

> PEDro Score: 8/10
> Patient: Included 90 patients who were similar to my patient
> Intervention:
> - Aquatic exercise program
> - Land-based resistance training program
> - Control group
>
> Outcome measures:
> - Quadriceps strength dynamometry
> - Six-minute Walk Test (6MWT)
> - Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)
> - SF-12 quality of life
> - Adelaide Activities Profile
> - Arthritis Self-Efficacy Scale

3. Wang T-J, Lee S-C, Liang S-Y, Tung H-H, Wu S-FV, Lin Y-P. Comparing the efficacy of aquatic exercises and land-based exercises for patients with knee osteoarthritis. Journal of Clinical Nursing 2011; 20(17-18):2609-2622.

> PEDro Score: 7/10
> Patient: Included 78 patients who were similar to my patient.
> Intervention:
> - Group aquatic program, from Arthritis Foundation Aquatics Program (AFAP) manual
> - Group land exercise program, from People with Arthritis Can Exercise (PACE) manual
> - Control group
>
> Outcome measures:
> - Knee Injury and Osteoarthritis Outcome Score (KOOS)
> - Knee ROM via goniometer
> - Six-minute Walk Test

Table 1. Comparison of PEDro Scores (as rated on PEDro)

	Lund *et al.*	Foley *et al.*	Wang *et al.*
Random			
Concealed allocation			
Baseline comparability			
Blind Subjects	No	No	No
Blind Therapists	No	No	No
Blind Assessors			
Adequate Follow-up			
Intention-to-Treat			No
Between Group			
Point Estimates & Variability			
Total Score	8/10	8/10	7/10

Based on the above comparisons, I have chosen to write this critically appraised paper on the articles by Lund *et al.* and Wang *et al.* due to the following: exclusion criteria of other joints with OA , focus on knees with OA and more recent publish dates . I also want to compare the results seen from treatment with a physical therapist versus treatment in community exercise groups.

Article: Lund H, Weile U, Christensen R, Rostock B, Downey A, Bartels EM, Danneskiold-Samsoe B, Bliddal H. A randomized controlled trial of aquatic and land-based exercise in patients with knee osteoarthritis. *Journal of Rehabilitation Medicine* 2008; 40(2):137-144.

Clinical Bottom Line: According to this study, land-based exercises may benefit individuals with primary knee OA more than aquatic exercises, but more confirming research is needed as the results are only mildly significant for some of the outcome measures. The study consisted of 71 subjects reporting a history of primary knee OA, without other knee or medical complications that would prevent them from aquatic exercise. Twenty-six subjects received aquatic therapy consisting of timed resistance and balance-based exercises. Twenty subjects received the same duration of resistance and balance-based exercises on land. Twenty-five subjects comprised the control group who received instructions to add no further exercises to any regimen already implemented per individual.

The authors reported that no outcomes measures were significantly different than the control group immediately after treatment. Three months after completing the treatment sessions, the aquatic group reported no change in pain level at rest or while walking, no change in KOOS ADL score and a decrease in knee flexor and extensor strength of -0.28 (95% CI: -0.51 to -0.04) compared to the control group. The land-based exercise group reported a decrease in pain level at rest by -8.1mm (95% CI: -15.8 to -0.4), no change in pain level while walking, no change in KOOS ADL score and an increase in knee flexor and extensor strength of 0.26 (95% CI: 0.00 to 0.52), compared to the control group. Minimal clinically important differences (MCID) were not mentioned by the authors or available to the assessor to evaluate the ability to notice such changes in the clinic.

The study's largest threat to validity was the decreased level of power attributed to the results because of the smaller-than-preferable number of subjects. Thus, the likelihood for a Type II error increased and the effect size decreased. No other major threats were found. While the clinical effectiveness of aquatic or land-based exercises for addressing pain, function and strength for patients with knee OA is not clear, the financial and time costs of treatment appear to be consistent with methods commonly employed.

Article PICO:
> **Population:** Patients with primary knee OA
> **Intervention:** Aquatic exercise guided by physiotherapy students
> **Comparison:**
> - Land-based exercise program guided by physiotherapy students
> - Control group, no additional exercise
>
> **Outcomes:**
> - Pain level at rest and while walking via VAS
> - Physical function via KOOS
> - Quadriceps and Hamstring Strength via isokinetic dynamometry

Blinding: Subjects and therapists were not blinded, but assessors were. As subjects and therapists are unable to be blinded to type of treatment through participation, this is not a threat to study validity.

Controls: The control group received instruction to continue previously established exercise regimes per individual, if present, but to not include any new exercises. This is an appropriate comparison group as these were the same instructions all other subjects received, with the only difference being the intervention they underwent. Differences shown from the outcomes can thus likely be attributed to the chosen intervention.

Randomization: Group assignments were randomly chosen using the opaque envelope method. According to the p-values reported, all baseline characteristics and baseline measurements were successfully randomized between groups. The only exception was body weight being significantly different between the aquatic and land-based exercise groups with a p-value of 0.03, showing the aquatic group to be an average of 13.5 kg heavier. This difference presents a minor threat to validity, but overall the groups were presented to be similar at baseline.

Study: This randomized control trial was completed by two intervention groups of 26 and 20 subjects focusing on the effect of aquatic and land-based exercise regimes, respectfully, and a control group of 25 participants. All subjects were asked to refrain from initiating additional exercise routines to what was already previously established per individual. Subjects participated in 50-minute sessions of their chosen intervention, twice a week for eight weeks. Each exercise session was regimented with music to include a ten-minute warm-up, twenty minutes of resistance exercises, ten minutes of balance/stability exercises, five minute of lower extremity stretches and a five-minute cool-down, as explicitly described in the study appendix.

Subjects were included in this study with a primary OA diagnosis from a physician and a blood test to confirm the lack of rheumatoid factor, therefore excluding rheumatoid arthritis (RA). Subjects were excluded if they exhibited characteristics that would prevent their participation in aquatic therapy, such as hydrophobia, incontinence and wounds; a previous history of knee conditions or intervention that would skew results concerning primary OA, such as peri-articular knee fracture, total knee replacement, inflammatory joint disease, or secondary knee OA; impairments that would contraindicate exercise such as heart or lung conditions or language and intellectual problems; and those who may be participating in other regimented exercise programs for other research.

Outcome measures: To assess the efficacy of aquatic or land-based exercise at delaying the need for total joint replacement surgery, pain level, physical function and quadriceps and hamstring strength are the most relevant outcomes, in that order. Measurements were taken prior to the start of treatment, directly after the eight weeks of treatment, and twenty weeks from treatment initiation or a 3-month follow-up. Each of these measures were taken by two blinded therapists, with non-specific experience in taking the measures.

There were no reported statistics of inter-rater or intra-rater reliability per measure, but the specificity of methods for consistent calibration, technique, direction and inability for subjects to see previous scores suggest a high potential for reliable outcomes measures taken. Authors cited one study of reliability for lower extremity dynamometry and replicated such techniques, but again, did not mention the numerical values of such reliability.

The authors cite that these measures have been validated in the literature for the population of subjects assessed, specifically the KOOS and dynamometry, for elders with primary knee OA. These two measures are currently the gold standards for this population. (11) A recent systematic review reports the KOOS, among 24 instruments identified, as the appropriate tool for accurately measuring patient-reported function in subjects with knee OA based on the reliability, face and construct validity. (12)

The authors do not discuss an MCID for any of the measures, but report using a change of 22mm (SD: 30.25mm) on the VAS for their power analysis, and report requiring 30 subjects per group to avoid a Type II error. One study suggests that a numerical decrease of one point on the numerical rating scale (NRS), comparable to 10mm on the VAS, is consistent with a patient's global impression of change (PGIC) when evaluated in a population with chronic osteoarthritis. (9) The assessor was unable to discern an MCID from the literature concerning the KOOS or quadriceps/hamstrings strength via isokinetic dynamometry.

Study losses: A total of eight subjects dropped out from the study (10.1%) and of all the subjects who completed the study, only one from the control group failed to complete the follow-up measures (1.4%). All completing subjects were analyzed within in their respective groups. Five subjects from the land-based group dropped out (20%), secondary to work, a non-related forearm fracture, and three because of increased pain levels. One subject from the aquatic group dropped out (3.7%), secondary to work. Two subjects dropped out from the control group (7.4%), one at baseline, and one secondary to moving abroad. Only the subjects in the land-based group who dropped out secondary to increased pain show losses related to interventions of the study.

An intention-to-treat analysis was performed to account for the losses and present the results conservatively, avoiding a Type I error of falsely assuming a positive result from treatment.

Summary of internal validity: This study has moderately high internal validity. Authors demonstrate appropriate randomization, blinding, valid outcomes measures and discuss the intention-to-treat analysis performed.

The difference of body weight between the two intervention groups at baseline presents a minor threat, especially as the group with the higher weight is on land. As increased weight is a significant factor of increased joint compression of the knees, and therefore likely increased pain in subjects with OA, this difference may compromise the compliance of the land-based group.

The only major threat to validity is the lack of power behind what the results report, according to the required number of subjects needed per group. Prior to initiating the study, authors were aware of needing 30 subjects per group to detect a statistically significant difference, and yet did not complete the study with that many, lowering the effect size of their results. Otherwise, the methodology of this study presented no flaws.

Evidence: Pain level via the VAS, physical function via the ADL section of the KOOS and quadriceps and hamstring strength via isokinetic dynamometry are the most relevant outcomes to answer this clinical question, and these measures were evaluated prior to the start of

treatment, directly after the eight weeks of treatment, and twenty weeks from the start. Further within-group comparison data and a direct strength comparison between the exercising groups would each be beneficial to illuminate overall trends seen. Results from the intention-to-treat analysis are reported here.

Table 2. Within-group 100 mm VAS **Pain at Rest** Means (SD) (SE after treatment)

	Baseline p= 0.14	8 weeks	20 weeks	% Change
Land-based	23.3 (18.8)	18.8 (3.3)	15.6 (2.8)	-33.0%
Aquatic	29.8 (23.5)	20.3 (3.2)	18.1 (2.7)	-39.2%
Control	15.5 (20.1)	27.2 (3.2)	23.8 (2.7)	+53.5%

With a reported p-value of 0.14, the baseline VAS scores for pain at rest are statistically similar between groups (Table 2). For the aquatic and land-based groups, the scores the authors presented trended downwards and the control group's mean score increased after the eight-week treatment time period before also trending downwards at the three-month follow-up. Considering the author's initial meaningful change of 22mm, none of the groups averaged that high of an increase or decrease of pain at rest. However, considering the study that recommended one level of change on the NRS scale as being meaningful, the aquatic group was the only one to exhibit a comparable change, and decrease in pain level at rest. (9) Assessor-calculated percentage changes demonstrate the highest relative change in the aquatic group.

Table 3. Between-group 100 mm VAS **Resting Pain** Group Mean Differences (95% CI)

	8 Weeks	20 Weeks
Land-based vs. Control	-5.5 (-14.6 to 3.6)	-8.1 (-15.8 to -0.4)
Aquatic vs. Control	-3.9 (-13 to 5.2)	-5.7 (-13.3 to 2.0)
Aquatic vs. Land-based	1.5 (-7.6 to 10.7)	-2.5 (-5.2 to 10.2)

The authors present a consistent pattern of confidence intervals ranging between positive and negative values, suggesting the majority of between-group comparisons of VAS pain scores at rest are not significantly different (Table 3). The only meaningful difference noted is between the land-based and control groups, suggesting a significant decrease in pain at rest seen at the three-month follow-up, potentially due to the addition of land-based exercises.

Table 4. Within-group 100 mm VAS **Walking Pain** Means (SD) (SE after treatment)

	Baseline p= 0.43	8 weeks	20 weeks	% Change
Land-based	53.0 (32.6)	51.5 (4.1)	50.1 (4.0)	-5.4%
Aquatic	59.8 (18.4)	55.8 (4.0)	52.9 (3.8)	-11.5%

| Control | 48.5 (31.9) | 58.1 (4.0) | 58.3 (3.5) | +20.2% |

With a reported p-value of 0.43, the baseline VAS scores for pain while walking are statistically similar between groups (Table 4). Walking presented as more painful for all groups compared to pain rated at rest (Table 2). There was also a much smaller change seen in the pain scores while walking instead of at rest, and similar downward trends in both of the exercise groups and an increase of pain in the control group.

Table 5. Between-group 100 mm VAS **Walking Pain** Group Mean Differences (95% CI)

	8 Weeks	20 Weeks
Land-based vs. Control	-6.6 (-18.0 to 4.8)	-8.2 (-19.7 to 2.7)
Aquatic vs. Control	-2.3 (-13.6 to 8.9)	-5.4 (-16.2 to 5.4)
Aquatic vs. Land-based	4.3 (-7.2 to 15.7)	2.8 (-8.2 to 13.8)

Again, the authors present confidence intervals ranging between positive and negative values, suggesting that none of between-group comparisons of VAS pain scores while walking are significantly different, despite the exercise groups' scores slightly decreasing and the control group's mean score increasing (Table 5).

Table 6. Within-group **KOOS ADL** (0-100) Means (SD) (SE after treatment)

	Baseline p= 0.51	8 weeks	20 weeks	% Change
Land-based	40.6 (13.6)	64.1 (2.3)	63.9 (2.7)	+57.4%
Aquatic	44.7 (18.1)	62.7 (2.3)	63.0 (2.6)	+40.9%
Control	39.6 (13.2)	61.1 (2.2)	61.4 (2.6)	+55.1%

With a reported p-value of 0.51, the baseline values for the ADL section of the KOOS instrument are statistically similar between groups (Table 6). All three groups trend towards higher scores, around 50% higher than baseline as calculated by the assessor, indicating fewer difficulties with ADLs that are typically provocative. All three groups' means remained within a 0.3 point difference during the three-month span between follow-ups, indicating that the majority of increase in function occurred during the treatment timeframe, regardless of group.

Table 7. Between-group **KOOS ADL** (0-100) Group Mean Differences (95% CI)

	8 Weeks	20 Weeks
Land-based vs. Control	3.1 (-3.4 to 9.5)	2.5 (-5.0 to 9.9)
Aquatic vs. Control	1.6 (-4.7 to 8.0)	1.6 (-5.7 to 8.9)
Aquatic vs. Land-based	-1.5 (-0.8 to 5.0)	-0.9 (-8.3 to 6.6)

The trend continues with further reported confidence intervals ranging between positive and negative values, suggesting that none of between-group comparisons of KOOS ADL scores

while walking are significantly different immediately after treatment or three months later (Table 7). Although the between-group comparisons revealed no choice treatment over the control after eight or twenty weeks, it is notable to mention that this is because all three groups improved in their ADL scores despite treatment, or lack thereof.

Table 8. Between-group **Strength Compilation** Standardized Mean Differences (95% CI)

	8 Weeks	20 Weeks
Land-based vs. Control	0.14 (–0.10 to 0.38)	0.26 (0.00 to 0.52)
Aquatic vs. Control	-0.16 (-0.39 to 0.07)	-0.28 (-0.51 to -0.04)

Baseline measurements of knee flexor and extensor strength are reported for each of the three chosen degrees of knee flexion, and complied strength measurements are reported for both of the follow-up times (Table 8). No baseline strength compilations or individual flexor or extensor data from follow-ups are reported. According to the reported follow-up comparisons, at the three-month follow-up the land-based group showed a significant increase in strength compared to the control group while the aquatic group showed a significant decrease in knee flexor and extensor strength compared to the control group. These differences are evidenced by the confidence intervals that remain in the positive and negative range, respectively.

Applicability of study results:
Benefits vs. Costs: Both exercise groups received the same amount of treatment in time of appointment and time of type of strength or balance training. Aquatic therapy may require additional financial cost considering therapist training and the facility required.

The mildly significant decreases in pain at rest and increases in strength seen three months after finishing the land-based exercise program may be worth the high potential for adverse effects to some patients. In this group, effects such as increased pain, swollen knees, and resultant dropping out from the exercises were reported by 44% of subjects who began the study.

The mildly significant decreases in strength may dissuade patients from aquatic therapy, however the level of potential adverse effects was much smaller, with only 11% of subjects reporting pain during treatment that did not lead to any dropouts. Authors reported adverse effects being six times more likely in the land-based group.

Feasibility of treatment: The interventions of this study can be readily applied in a clinical setting. The timeframes of treatment sessions and the overall eight weeks are consistent with a typical treatment regimen, and would be expected to be covered by insurance companies. The procedures were decently outlined in the attached appendix, to be reproduced with no extra training. The lack of a home exercise program increases the likelihood of high compliance, however the high potential for a painful treatment with the land-based regime counteracts that level of high compliance.

Summary of external validity: At first glance, the population in this study appears to be representative of the larger patient population seen in the clinic. However, the many

exclusionary criteria applied to select the treatment populations disregards the high presence of comorbidities and previous treatments in patients in the clinic. The results of this study may be readily generalizable to patients with few comorbidities, but not the entire patient population with knee OA.

Article: Wang T-J, Lee S-C, Liang S-Y, Tung H-H, Wu S-FV, Lin Y-P. Comparing the efficacy of aquatic exercises and land-based exercises for patients with knee osteoarthritis. Journal of Clinical Nursing 2011; 20(17-18):2609-2622.

Clinical Bottom Line: According to this study, a land-based or aquatic exercise class may benefit individuals with primary knee OA, but more confirming research is needed as the results are only mildly significant. The study consisted of 78 subjects reporting a history of primary knee OA, without other knee or medical complications that would prevent them from exercise. Twenty-six subjects participated in an aquatic exercise class based on the AFAP manual, consisting of timed flexibility, aerobic and resistance exercises. Twenty-six subjects received the same duration of flexibility, aerobic and balance-based exercises on land in a class based on the PACE manual. Twenty-six subjects comprised the control group, with no further instruction mentioned.

        The authors report that KOOS ADL scores, 6MWT distances and knee extension measurements for both exercising groups were significantly different and improved compared to the control group after the entire twelve weeks of treatment. Authors only report mean changes and 95% confidence intervals for the KOOS pain scores as their primary outcome, being 8.8 (95% CI=4.8 -12.8) and 9.1 (95% CI=5.1-13.2) for the aquatic and land-based groups, respectively. Although this outcome was not shown to be a statistically significant decrease from the control group, according to the MCID of eight points proposed by Roos *et al.* within both groups a clinically significant decrease in pain level is demonstrated after twelve weeks of treatment. (8) This was the only measure with an associated MCID to be evaluated by the assessor.

        The study had no significant threats to internal validity. However, as the functional ability of subjects upon beginning treatment is likely much greater than patients in the clinic, the ability to apply results to a clinical population is questionable. While the clinical effectiveness of an aquatic or land-based exercise class for addressing pain, function and knee extension for patients with knee OA is not clear, the financial and time costs of treatment appear to be consistent with methods commonly available and the protocols employed would be readily applied in a clinical setting.

Article PICO:
    Population: Seventy-eight adults aged over 55 years with knee OA diagnosed by a physician.
    Intervention: Aquatic exercise class based on AFAP manual taught by instructor.
    Comparison:
- Land-based exercise class based on PACE manual taught by instructor.
- Control group, no exercise

    Outcomes:
- Pain and physical function (ADL score) via KOOS
- Knee ROM via goniometry
- 6-Minute Walk Test

Blinding: Subjects and group exercise instructors were not blinded, but nurse student assessors were. As subjects and instructors are unable to be blinded to type of treatment through participation, this is not a threat to study validity.

Controls: There is no explicit mention of instruction given to the control group. As an exclusion criterion was more than an hour of exercise per week over the last two months, it can be inferred that no further exercise was added to the control group's activities of daily living to differentiate between the addition of either of the exercise interventions. This is an appropriate control group to target the effect of the interventions.

Randomization: This study was randomized by an assistant, who was not involved in recruiting participants, who used a computer system to randomly allocate participants into one of the three groups. Thus, the randomization process was successfully concealed and the authors reported that groups were successfully randomized, exhibiting p-values greater than .05 in all distinguishing, demographic and descriptive characteristics.

Study: This randomized control trial was completed by three groups of 26 subjects, two intervention groups focusing on the effect of aquatic and land-based exercise class regimes and a control group. There were no explicit directions for the control group.

       Subjects participated in 60-minute class sessions of their chosen intervention, three days a week for twelve weeks. Each exercise session was based off guidelines from the AFAP and PACE manuals, and regimented to include a five-minute warm-up, ten minutes of flexibility training, ten minutes of aerobic training, ten minutes of upper body training, ten minutes of lower body training and a five-minute cool-down, as explicitly described in Table 1 of the authors' study. Currently, there is only preliminary evidence to suggest that these guidelines may be effective at increasing function and reducing pain for subjects with OA (2). Each exercise was using body weight and participants were instructed in the Borg CR-10 scale for perceived exertion to maintain a level of 3-4 throughout the class.

       Subjects were included in this study if they consented, were at least 55 years old and had an OA diagnosis from a physician, based on symptoms and x-ray. Subjects were excluded if they had a history for knee condition intervention that would skew results concerning OA, such as intra-articular corticosteroid injections within the past 30 days, total knee replacement (TKR); impairments that would contraindicate exercise such as heart or lung conditions or uncontrolled epilepsy; and those who presently had exercise regimes totaling more than an hour per week over the last two months.

Outcome measures: The outcomes of pain level, physical function, 6MWT and knee flexion and extension measurements are the most relevant outcomes addressed in this study to assess the clinical question concerning the efficacy of aquatic or land-based exercise at delaying the need for total joint replacement surgery. Measurements were taken prior to the start of treatment, halfway through the protocol after six weeks of treatment, and directly after the entire twelve weeks of treatment. Each of these measures were taken by five blinded nursing students, with standardized instructions, in the consistent order of the questionnaire, knee ROM tests and then the 6MWT.

The authors presented the following reliability measures per objective measure employed:

- The KOOS has a reported intra-class correlation (ICC) of 0.78-0.97 for patients after TKR, and 0.70-0.93 for patients with anterior cruciate ligament injury. Thus, a high ICC may be inferred for patients with OA. Also, the authors report that the KOOS has an alpha coefficient of 0.88 in this study, demonstrating a moderately high reliability.
- The 6MWT was reported to have an ICC of 0.94 in previous studies, and the authors report the practice round revealed a similar high test-retest reliability of 0.85.
- Goniometric measurements were reported to have good test-retest reliability from a previous study by the authors, with an ICC of 0.96-0.99, and the authors reported the measures taken at baseline revealed similar levels of high reliability with an ICC of 0.78-0.97.

The authors cite that the KOOS has been validated in the literature for the population of subjects assessed. This measure is currently the gold standard for this population. (11) Again, a recent systematic review reports the KOOS as the appropriate tool for accurately measuring patient-reported function in our population of subjects with knee OA based on the reliability, face and construct validity. (11) The 6MWT has been reported as a valid measure for assessing and distinguishing between pain and level of function in this population of subjects. (10) Knee extension has been reported as more indicative of loss of function compared to flexion, and is therefore the valid, chosen range to be evaluated . (5)

The authors report the MCID for the KOOS as a score change of at least eight points in any of the subsections, as determined by Roos *et al.* (8) They do not report an MCID for the 6MWT or goniometry. I was unable to find numerical MCIDs for either measure, although the 6MWT was found to have a moderate effect size, and thus responsiveness, at reflecting clinical change compared to other functional objective tests often employed in the clinic, like the Timed-Up-and-Go (TUG test). (4)

Study losses: A total of six subjects were dropped from the analysis of the study (7.1%) yet all but one subject (1.2%) completed the study interventions. The subjects who were analyzed remained within in their respective groups. Subjects that were dropped from the analysis (7.1%), were not excluded for reasons directly attributable to the intervention.

Two subjects from the land-based group were lost to follow-up: one at allocation due to disinterest with treatment type, and one at the halfway point due to other obligations. Two subjects from the aquatic group were lost to follow-up: one at the halfway point due to a herpes flare up, and one at the endpoint due to travel. Two subjects from the control group were lost to follow-up: one at the halfway point due to other obligations and one at the endpoint due to a hospital admission for pneumonia.

There was no mention of an intention-to-treat analysis, possibly due to all subjects completing the intervention protocol, just missing the follow-up measures for various reasons.

Summary of internal validity: This study has high internal validity. Authors demonstrate appropriate randomization, blinding, valid and reliable outcomes measures, similar groups randomized at baseline, and adequate group sizes. Prior to initiating the study, authors were aware of needing 18 subjects per group to detect a statistically significant difference, and thus

completed the study with 26 subjects per group to ensure a medium to large effect size for their results.

      The only minor threat to validity is the fact that authors do not discuss an intention-to-treat analysis for the subjects that dropped out. Likely this is due to that fact that the subjects completed the study and only missed the follow-up measurements.

Evidence: Pain level and physical function via the pain and ADL sections of the KOOS, knee extension ROM via goniometry and 6MWT distances are the most relevant outcomes to answer this clinical question, and these measures were evaluated prior to the start of treatment, halfway through after six weeks of treatment, and directly after the twelve weeks of treatment. Higher KOOS scores, higher 6MWT distances and fewer degrees from full extension are preferable as they indicate a higher level of function, and a lower level of impairment.

      The authors present comparisons between the baseline control group's scores and the end results of each intervention group. These results are not reported in this appraisal as they discount the improvements seen in the control groups to magnify changes that may not be significantly due to intervention alone.

Table 9. Within-group **KOOS Pain score** (0-100) Means (SD)

	Baseline p=0.56	6 weeks p= 0.60	12 weeks p=0.23
Aquatic	61 (20)	70 (19)	72 (18)
Land	65 (14)	72 (15)	76 (15)
Control	66 (18)	67 (19)	68 (18)

The authors report using a chi-square test to evaluate the data. With none of the p-values being less than 0.05, none of the groups' pain levels represented by the averaged KOOS scores are statistically different at each of the time points (Table 9). The baseline scores show that the groups started with pain levels that were statistically similar. Thus, pain level was not significantly changed by aquatic or land-based exercise as compared to the control group at each time of measurement. However, only within both exercise groups did the average scores increase by greater than 8 points to achieve the MCID cited by Roos *et al.* (8)

Table 10. Within-group **KOOS ADL score** (0-100) Means (SD)

	Baseline p=0.67	6 weeks p= 0.21	12 weeks p=0.022
Aquatic	73 (20)	75 (18)	76 (16)
Land	75 (16)	79 (15)	82 (14)
Control	70 (19)	70 (19)	69 (18)

The control group demonstrated little change, while both intervention groups trended towards higher ADL scores (Table 10). The only significant difference between the KOOS ADL scores

was reported to be at the 12-week follow-up. A p-value of 0.022 shows that there is a small likelihood that the groups are similar at this time point.

Table 11. Within-group **Knee extension ROM** (degrees) Means (SD)

	Baseline p=0.57	6 weeks p= 0.044	12 weeks p=0.017
Aquatic	3.7 (1.3)	2.7 (1.2)	2.4 (2.2)
Land	3.7 (1.2)	2.7 (1.2)	2.0 (1.4)
Control	3.4 (1.2)	3.4 (1.2)	3.3 (1.1)

For knee extension ROM measurements, lower numbers indicate that subjects are lacking fewer degrees and are thus closer to achieving full knee extension ROM. At baseline, the groups are not reported to be statistically different with a p-value of 0.57, representing successful randomization (Table 11). The control group demonstrates minimal change over the duration of the study while both intervention groups display downward trends, which are favorable. At both the 6-week and 12-week follow-ups, the groups are reported to be statistically different with p-values less than 0.05.

Table 12. Between-group **6MWT Distance** (feet) Means (SD)

	Baseline p=0.70	6 weeks p= 0.14	12 weeks p=0.015
Aquatic	330.9 (76.5)	368.2 (71.3)	386.0 (75.8)
Land	339.8 (72.7)	351.8 (77.6)	381.0 (70.4)
Control	321.5 (85.8)	325.0 (83.4)	329.1 (82.3)

A higher number on the 6MWT represents a further distance covered during six minutes of ambulation. All three groups trended towards increasing distances. At baseline and at the 6-week follow-up, there was no statistical difference reported between groups with a p-value of 0.14. At the 12-week follow-up, a statistical difference was shown with a p-value of 0.015, showing that the increase in distance was more significant for the exercise groups compared to the control group (Table 12).

Applicability of study results:

Benefits vs. Costs: Overall benefits are reported for both exercise groups in the form of increased ADL functional levels and 6MWT walk time after twelve weeks of treatment and increased knee extension ROM after six weeks of treatment when compared to the control group. Pain levels within the intervention groups were reported to decrease by values reflective of the MCID, suggesting a clinical difference despite an insignificant statistical difference between groups.

Both exercise groups received the same amount of treatment in time of appointment and time of type of training. These are comparable to community exercise classes, but may be excessive compared to timing of appointments generally seen in outpatient clinics. Aquatic therapy in a clinic may also require additional financial cost considering therapist training and the facility required.

Adverse effects due to intervention include increased pain reported by 7.7% of subjects in the land-based exercise group, and dizziness reported by 3.8% of subjects in the aquatic group. No subjects were reported to have stopped intervention due to adverse effect, demonstrating a minor cost of treatment for reported benefits of increased functional ability after twelve weeks of treatment.

Feasibility of treatment: The interventions used in this study could be applied in a clinical setting. Although both timeframes of treatment sessions and the overall twelve weeks are longer than a typical treatment regimen, the procedures were decently outlined by the authors and are able to be reproduced with no extra training. The lack of a home exercise program and few adverse effects reported increase the likelihood of high compliance. Because interventions were in the form of exercise classes, other psychological or availability factors would likely present issues in transitioning to a clinical setting.

Summary of external validity: The high internal validity of the study suggests a high potential to generalize these results to the larger population. Participants were community-dwelling residents with many physical characteristics that are representative of typical patients with knee OA. However, subjective characteristics tended to reflect higher levels of functioning compared to patients being seen in the clinic. Authors note this distinction by mentioning how the average KOOS scores of subjects in this study ranged from 60.1-74.1 while another study cites the average patient's KOOS scores ranging from 20.1-41.7, a drastic difference.

Synthesis/Discussion

Rankings of Methodological Quality: The PEDro scores for these evaluated studies were 8 and 7/10, respectively. PEDro scores need to be greater than or equal to 5 to represent moderate to high quality. (7) These papers met this criterion and thus their methodological quality can be described as high.

The areas that were lacking from these articles are as follows:

> Blinding: Neither of the studies reported subject or therapist blinding, but this does not affect validity in a large way due to the necessity of patient and therapist awareness of treatment techniques.

> Intention to treat: Wang *et al*. did not report an intention-to-treat analysis, however their losses were due to subjects' inability to attend follow-up sessions, not due to incompliance or dropping out from treatment.

Population eligibility criteria & number of subjects: Both studies had similar inclusion and exclusion criteria for subjects. The study by Lund *et al*. required a blood test to rule out RA and both studies required subjects to receive a diagnosis of primary knee OA from a physician. The study by Lund *et al*. had more strict exclusionary criteria, denoting hydrophobia, incontinence, wounds, language and intellectual problems as restricting to randomization and participation. The study by Wang *et al*. excluded those with uncontrolled epilepsy and who have received an intra-articular cortisone injection within the month prior to treatment. Both studies excluded subjects with prior history of knee conditions or previous treatment, other impairments that would contraindicate exercise such as heart or lung conditions and subjects who were currently enrolled in an exercise regime.

Power: Both studies reported assessing the number of subjects needed to demonstrate an appropriate level of power. The study by Lund *et al*. reported requiring 30 subjects per group, and they failed to retain those numbers. The study by Wang *et al*. reported requiring eighteen subjects per group, and they achieved that with twenty-six subjects.

Treatment Differences: Both studies had three treatment groups: an aquatic exercise group, a land-based exercise group and a control group. Both of the studies were consistent in the type and timing of exercises selected between the aquatic and land-based groups. The duration of treatment was 50-minute sessions per intervention, twice a week for eight weeks in the study by Lund *et al*. and 60-minute sessions per intervention, three days a week for twelve weeks in the study by Wang *et al*. The exercises chosen by the authors of Wang *et al*. were reported to stem from guidelines of the AFAP and PACE manuals. The major difference was that the subjects in the study by Wang *et al*. participated in group exercise classes compared to the individual treatment sessions that the subjects in the study by Lund *et al.* received.

Methodology Flaws: The treatments and outcomes in each study were appropriate to target the effectiveness of addressing impairments related to knee OA with exercise. One flaw in demonstrating a comparison between groups was that in the study by Wang *et al*. the improvement in scores is evidenced by the change from the control group's baseline scores to the treatment groups' ending scores. This comparison basically negates the use of the control

group and discounts the factor of time. Thus, the results presented here are reports of only the within-group changes. This was the primary flaw noted by the assessor.

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