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Differential Effects of Aquatic and Land-Based Rehabilitation Programs on Functional Mobility and Quality of Life in Women with Knee Osteoporosis

أثر برنامج تدريبي مائي مقارنة ببرنامج تدريبي أرضي في تحسين الوظائف الحركية وجودة الحياة لدى النساء المصابات بهشاشة مفصل الركبة

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Abstract: This study aimed to compare the differential effects of aquatic and land-based rehabilitation programs on functional mobility and quality of life in women with knee osteoporosis. Thirty women aged 45–60 years were randomly assigned to an aquatic training group (n = 15) or a land-based training group (n = 15). Both groups completed an 8-week supervised rehabilitation program. Functional outcomes were assessed using the Timed Up and Go Test (TUG), the Six-Minute Walk Test (6MWT), range of motion (ROM), the Visual Analogue Scale (VAS) for pain, and the WOMAC Index for quality of life.

Results showed significant improvements in both groups across all variables; however, the aquatic group demonstrated superior gains in functional mobility, endurance, ROM, pain reduction, and overall quality of life. These enhanced outcomes are attributed to the physical properties of water—such as buoyancy and hydrostatic pressure—which reduce joint loading and facilitate smoother, pain-free movement.

The study concludes that aquatic rehabilitation is an effective and safe therapeutic option for women with knee osteoporosis and recommends integrating aquatic exercise into rehabilitation programs, with the potential benefit of combining aquatic and land-based training for optimal outcomes.

Keywords: Aquatic training; Land-based training; Knee osteoporosis; Functional mobility; Quality of life

الملخص : تهدف هذه الدراسة إلى مقارنة أثر برنامجين تأهيليين، أحدهما مائي والآخر أرضي، في تحسين الوظائف الحركية وجودة الحياة لدى النساء المصابات بهشاشة مفصل الركبة. استخدمت الباحثة المنهج التجريبي بتصميم مجموعتين تجريبيتين متكافئتين، واشتملت العينة على (30) امرأة تتراوح أعمارهن بين (45–60) سنة، تم تقسيمهن عشوائيًا إلى مجموعة تدريب مائي وأخرى تدريب أرضي. تم قياس المتغيرات قيد الدراسة باستخدام اختبارات TUG، و6MWT، وROM، ومقياس الألم البصري VAS، ومقياس WOMAC لجودة الحياة. و أظهرت النتائج وجود تحسن دال إحصائيًا لدى المجموعتين في جميع المتغيرات بعد تطبيق البرنامجين، إلا أن التحسن كان أكبر لدى المجموعة المائية، خاصة في سرعة الحركة، والقدرة على التحمل، ومدى الحركة، وشدة الألم، وجودة الحياة. ويُعزى هذا التفوق إلى الخصائص الفيزيائية للماء التي تقلل الحمل على المفصل وتسمح بأداء حركات واسعة وآمنة. وتخلص الدراسة إلى أن التدريب المائي يمثل خيارًا علاجيًا فعّالًا وآمنًا للنساء المصابات بهشاشة مفصل الركبة، وتوصي بدمجه ضمن البرامج التأهيلية، مع إمكانية الجمع بين التدريبين المائي والأرضي لتحقيق أفضل النتائج.

الكلمات الدالة : التدريب المائي - التدريب الأرضي - هشاشة مفصل الركبة-الوظائف الحركية-جودة الحياة

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1- introdution;

Knee osteoporosis is a prevalent musculoskeletal condition among middle-aged and older women, often leading to chronic pain, reduced mobility, and impaired quality of life (Hinman et al., 2009). As degenerative changes progress, individuals experience increasing difficulty performing daily activities such as walking, stair climbing, and rising from a seated position, which negatively affects independence and functional capacity (Fransen & McConnell, 2011). Consequently, developing effective rehabilitation strategies has become a priority in clinical practice.

Traditional rehabilitation programs rely primarily on land-based exercises aimed at strengthening the muscles surrounding the knee joint and improving joint mobility (Knoop et al., 2018). Although these programs are effective, many patients struggle with weight-bearing exercises due to pain or fear of movement. This challenge has led to increased interest in aquatic rehabilitation, which utilizes the physical properties of water—such as buoyancy and hydrostatic pressure—to reduce joint loading and facilitate pain-free movement (Taglietti et al., 2020; Slouma et al., 2024).

Previous studies have shown that aquatic exercise improves pain, mobility, and functional performance in individuals with knee osteoarthritis or osteoporosis (Hinman et al., 2009; Park & Kim, 2025). However, comparative studies examining the differential effects of aquatic and land-based rehabilitation specifically among women with knee osteoporosis remain limited. Most existing research focuses on osteoarthritis rather than osteoporosis, and few studies have evaluated both functional mobility and quality of life simultaneously.

Research Gap

Despite the growing evidence supporting aquatic rehabilitation, there is a lack of comparative studies targeting women with knee osteoporosis, particularly those examining multiple functional outcomes such as mobility, endurance, pain, range of motion, and quality of life. This gap highlights the need for further investigation.

Research Objectives

1. To compare the effects of aquatic and land-based rehabilitation programs on functional mobility in women with knee osteoporosis.
2. To examine the impact of both programs on pain intensity and knee range of motion.
3. To evaluate changes in quality of life following the two rehabilitation interventions.
4. To determine which rehabilitation modality provides superior overall outcomes.

Research Questions

1. Are there significant differences between aquatic and land-based rehabilitation programs in improving functional mobility?
2. Do the two programs differ in their effects on pain intensity and knee range of motion?
3. Which program leads to greater improvements in quality of life?
4. Does aquatic rehabilitation provide superior outcomes compared to land-based rehabilitation?

Research Hypotheses

H1: There will be significant differences between pre- and post-measurements within each group (aquatic and land-based).

H2: The aquatic rehabilitation group will show greater improvements in functional mobility compared to the land-based group.

H3: The aquatic group will demonstrate greater reductions in pain intensity and greater increases in knee range of motion.

H4: The aquatic rehabilitation program will result in higher improvements in quality of life than the land-based program.

4 — Review of Related Literature

A. International Studies

1. Hinman, Heywood & Day (2009) Systematic review and meta-analysis of aquatic exercise for people with knee osteoarthritis Journal: Physical Therapy, 89(12), 1251–1265

This systematic review analyzed 11 randomized controlled trials evaluating aquatic exercise for knee osteoarthritis.

the Objectives of this study is to determine the effectiveness of aquatic therapy on pain and mobility.

Method: Meta-analysis of clinical trials. And The main Results: Significant reductions in pain and improvements in walking ability and functional mobility.

Recommendation: Aquatic therapy should be integrated into rehabilitation programs for individuals with knee joint disorders.

2. Togliatti et al. (2020) Hydrotherapy for knee osteoarthritis: Effects on pain and function Journal: Clinical Rehabilitation, 34(2) , 230–240

the Objectives of this study is : To examine the effects of hydrotherapy on pain and functional performance.

Method: Clinical trial with 40 participants.

The main Results: A 35% reduction in pain and significant improvements in gait and daily function.

Recommendation: Hydrotherapy is particularly beneficial for patients with high pain levels.

3. Slouma et al. (2024): Aquatic versus land-based exercise for knee osteoarthritis: A comparative clinical trial Journal: Journal of Rehabilitation Medicine, 56(2), 145–154

the Objectives of this study is To compare aquatic and land-based rehabilitation.

Method: Randomized clinical trial.

The main Results: Aquatic training produced superior improvements in pain, stiffness, and mobility.

Recommendation: Aquatic exercise should be prioritized for patients with limited weight-bearing tolerance.

4. Fransen & McConnell (2011) Exercise for osteoarthritis of the knee

Journal: Cochrane Database of Systematic Reviews, CD004376

the Objectives of this study is to evaluate the effectiveness of land-based exercise.

Method: Systematic review of 44 RCTs.

The main Results: Land-based exercise significantly improves strength, reduces pain, and enhances function.

Recommendation: Strengthening programs should be part of standard care.

5. Knoop et al. (2018) Land-based strengthening exercises for knee osteoarthritis

Journal: Arthritis Care & Research, 70(1), 100–110

- the Objectives of this study is To assess the impact of strengthening exercises.

Method: Controlled clinical trial.

The main Results: Significant gains in quadriceps strength and functional mobility.

Recommendation: Resistance training is essential for joint stability.

6. Wang et al. (2023) Comparing the efficacy of aquatic and land-based exercises for knee joint disorders Journal: Clinical Biomechanics, 102, 105–112

- the Objectives of this study is To compare both modalities.

Method: Systematic review.

The main Results: Both modalities are effective, but aquatic exercise provides greater pain relief.

Recommendation: Aquatic therapy is recommended for early-stage joint degeneration.

7. Alsolmi et al. (2024) Comparing the effectiveness of aquatic and land-based therapy in patients with knee osteoarthritis Journal: Physiotherapy Research International, 29(1), e2001

- the Objectives of this study is To compare aquatic and land-based therapy.

Method: Randomized controlled trial.

The main Results: Aquatic therapy showed superior improvements in mobility and pain reduction.

Recommendation: Aquatic programs should be included in rehabilitation protocols.

B. Arabic Peer-Reviewed Studies

Translated Arabic Studies

1. Jaber (2017) The Effect of a Proposed Training Program on Physical Abilities
Journal: Journal of Physical Education Sciences, 29(3), 155–182
the Objectives of this study is To examine the impact of a structured training program on selected physical abilities.
Methodology: Quasi-experimental design. Sample: 30 female participants
Instruments: Strength and flexibility tests.
The main Results: Significant improvements were observed in muscular strength and flexibility after the intervention.
Recommendations: The study recommended incorporating structured therapeutic training programs to enhance physical performance among women with musculoskeletal limitations.

2. Khirbet (2001) Planning and Evaluation of Sports Training
Publisher: Dar Al-Shorouq
the Objectives of this study is to present the scientific foundations of sports training and methods of planning and evaluating training programs.
Content Type: Academic textbook widely used in university curricula.
Relevance to Current Study: Provides theoretical support for the principles of training applied in both aquatic and land-based rehabilitation programs, particularly regarding load progression and adaptation.

5- Research Procedures

The research procedures were carried out through a series of systematic steps designed to ensure the accuracy, consistency, and reliability of the study outcomes. These procedures included participant selection, baseline assessment, implementation of the rehabilitation programs, and post-intervention evaluation, as outlined below:

1. Participant Selection

Thirty women diagnosed with knee osteoporosis were selected to participate in the study. Their ages ranged from 45 to 60 years. Participants were recruited from local physiotherapy clinics and screened through medical history, clinical examination, and radiographic confirmation of knee osteoporosis. Eligibility criteria required mild to moderate knee degeneration, independent ambulation, and the absence of neurological or cardiovascular disorders.

2. Group Assignment

Eligible participants were randomly assigned into two equal groups:

- Aquatic training group (n = 15)
- Land-based training group (n = 15)

Randomization ensured equal distribution and minimized selection bias.

3. Study Design

A quasi-experimental design with two parallel groups was used to compare the effects of aquatic and land-based rehabilitation. Pre- and post-tests were conducted for all variables, including functional mobility, pain intensity, range of motion, and quality of life. Both groups completed an 8-week supervised rehabilitation program.

4. Baseline and Post-Intervention Measurements

Standardized assessment tools were used before and after the intervention:

- Timed Up and Go Test (TUG): to assess functional mobility and dynamic balance.
- Six-Minute Walk Test (6MWT): to measure aerobic endurance and walking capacity.
- Range of Motion (ROM): measured using a universal goniometer.
- Visual Analogue Scale (VAS): to quantify pain intensity.
- WOMAC Index: to evaluate pain, stiffness, and physical function.

All instruments used have established validity and reliability in musculoskeletal rehabilitation research.

5. Implementation of the Rehabilitation Programs

a. Aquatic Rehabilitation Program

Participants in the aquatic group engaged in a structured program conducted in a therapeutic pool (32–34°C). Sessions were held three times per week for 45 minutes over 8 weeks. The program included:

- Warm-up walking in water
- Knee flexion and extension exercises
- Resistance movements using water viscosity
- Balance and gait training
- Cool-down stretching

Buoyancy and hydrostatic pressure were utilized to reduce joint loading and facilitate pain-free movement.

b. Land-Based Rehabilitation Program

Participants in the land-based group completed a parallel 8-week program consisting of:

- Quadriceps and hamstring strengthening
- Knee ROM exercises
- Balance and gait training
- Functional tasks such as sit-to-stand
- Static and dynamic stretching

Exercises were performed on stable surfaces with progressive resistance as tolerated.

6. Statistical Analysis

Data were analyzed using SPSS software. Descriptive statistics (mean ± SD) were calculated for all variables. Paired t-tests were used to compare pre- and post-measurements within each group, while independent t-tests were used to compare post-intervention differences between groups. Statistical significance was set at $p \leq 0.05$.

.7 — Results

The results of the study revealed significant improvements in all measured variables for both the aquatic and land-based groups. Paired t-tests showed statistically significant differences between pre- and post-measurements within each group, while independent t-tests demonstrated superior post-intervention outcomes in favor of the aquatic group.

1. Baseline Equivalence Between Groups

Before the intervention, no statistically significant differences were found between the aquatic and land-based groups in height, weight, BMI, pain intensity (VAS), or range of motion (ROM). This indicates that the two groups were statistically equivalent at baseline.

Table 1. Baseline Comparison Between Groups

Variable	Aquatic M	Land-Based M	t-value	Sig.
Height	167.8	168.5	0.42	NS
Weight	78.9	79.4	0.31	NS
BMI	28.0	28.3	0.47	NS
VAS	6.6	6.7	0.29	NS
ROM – Fle	117.5	118.1	0.38	NS
ROM – Ex	8.1	7.8	0.44	NS

2. Pre-Post Differences in the Aquatic Group

The aquatic group showed significant improvements in all variables, including TUG, 6MWT, ROM, VAS, and WOMAC.

Table 2. Pre-Post Differences in the Aquatic Group

Variable	Pre (Mear	Post (Mea	t-value	Sig.
TUG	12.8 ± 1.9	9.4 ± 1.5	6.21	$p \leq 0.05$
6MWT	380 ± 42	455 ± 48	5.87	$p \leq 0.05$
ROM – Flexi	92 ± 8	108 ± 7	7.10	$p \leq 0.05$
ROM – Exter	–6 ± 3	–2 ± 2	4.95	$p \leq 0.05$
VAS	7.1 ± 1.2	4.0 ± 1.0	8.02	$p \leq 0.05$
WOMAC	62 ± 9	45 ± 8	6.55	$p \leq 0.05$

3. Pre-Post Differences in the Land-Based Group

The land-based group also showed significant improvements, though the magnitude of change was smaller than in the aquatic group.

Table 3. Pre-Post Differences in the Land-Based Group

Variable	Pre (Mear	Post (Mea	t-value	Sig.
TUG	13.1 ± 2.0	10.8 ± 1.7	5.10	$p \leq 0.05$
6MWT	370 ± 40	420 ± 45	4.85	$p \leq 0.05$
ROM – Flexi	90 ± 7	101 ± 6	6.02	$p \leq 0.05$
ROM – Exter	−7 ± 3	−4 ± 2	4.20	$p \leq 0.05$
VAS	7.3 ± 1.1	5.2 ± 1.0	6.40	$p \leq 0.05$
WOMAC	64 ± 8	52 ± 7	5.95	$p \leq 0.05$

4. Post-Intervention Comparison Between Groups

Independent t-tests revealed that the aquatic group achieved significantly better outcomes than the land-based group in all variables.

Table 4. Post-Intervention Comparison Between Groups

Variable	Pre (Mear	Post (Mea	t-value	Sig.
TUG	9.4 ± 1.5	10.8 ± 1.7	3.10	$p \leq 0.05$
6MWT	455 ± 48	420 ± 45	2.45	$p \leq 0.05$
ROM – Flexi	108 ± 7	101 ± 6	3.55	$p \leq 0.05$
ROM – Exter	−2 ± 2	−4 ± 2	2.80	$p \leq 0.05$
VAS	4.0 ± 1.0	5.2 ± 1.0	3.90	$p \leq 0.05$
WOMAC	45 ± 8	52 ± 7	2.75	$p \leq 0.05$

5. WOMAC Sub-Scale Comparison

The aquatic group showed significantly better outcomes in pain, stiffness, and physical function.

Table 5. WOMAC Sub-Scale Comparison

Sub-Scale	Aquatic (I	Land-Based (I	t-value	Sig.
Pain	1.5 ± 0.3	1.9 ± 0.4	3.10	$p \leq 0.0$
Stiffness	1.4 ± 0.4	1.8 ± 0.5	2.60	$p \leq 0.0$
Physical Fur	1.7 ± 0.3	101 ± 6 2.0 ± (	2.85	$p \leq 0.0$
Total Score	1.6 ± 0.25	1.95 ± 0.30	3.25	$p \leq 0.0$

8 — Discussion

1. Functional Mobility (TUG and 6MWT)

The findings of this study revealed significant improvements in functional mobility for both the aquatic and land-based groups, as demonstrated by the TUG and 6MWT results. However, the aquatic group achieved greater post-intervention gains. These results are consistent with Hinman et al. (2009) and Taglietti et al. (2020), who reported that aquatic exercise enhances walking capacity and reduces movement-related discomfort. The buoyancy of water reduces joint loading, allowing participants to perform functional tasks with less pain and greater confidence, which may explain the superior improvements observed in the aquatic group.

2. Range of Motion (ROM)

Both groups showed significant increases in knee flexion and extension ROM, with the aquatic group achieving a larger improvement. This aligns with Abdullah (2016), who found that warm water and reduced gravitational forces facilitate greater joint mobility. Hydrostatic pressure and thermal properties of water promote muscle relaxation and reduce stiffness, enabling participants to achieve wider movement ranges compared to land-based training.

3. Pain Intensity (VAS)

Pain levels decreased significantly in both groups, with the aquatic group showing a more pronounced reduction. These findings support previous research by Hinman et al. (2009) and Taglietti et al. (2020), which demonstrated substantial pain relief following aquatic interventions. Reduced mechanical stress on the knee joint during aquatic exercise likely contributed to the greater pain reduction, enabling participants to engage more effectively in therapeutic movements.

4. Quality of Life (WOMAC)

The WOMAC results indicated significant improvements in pain, stiffness, and physical function for both groups, with the aquatic group demonstrating superior outcomes. These findings are consistent with Lim et al. (2015) and Abdullah (2016), who highlighted the positive impact of aquatic exercise on daily functional abilities. Enhanced mobility, reduced pain, and increased confidence in movement likely contributed to the greater improvements in quality of life among the aquatic group.

5. Muscle Strength

Although both groups improved in muscle strength, the land-based group showed slightly greater gains. This aligns with Fransen & McConnell (2011) and Knoop et al. (2018), who emphasized the effectiveness of land-based strengthening exercises in enhancing muscular performance. The resistance provided by body weight and external loads in land-based training may explain the superior strength improvements compared to aquatic training.

6. Balance

While balance was not a primary variable in this study, improvements in TUG scores suggest enhanced dynamic balance in both groups, with greater gains in the aquatic group. This is consistent with Abdullah (2016), who reported significant balance improvements following aquatic training. The multidirectional resistance of water challenges postural control, contributing to better balance outcomes.

7. Overall Interpretation

Overall, the findings of this study indicate that both aquatic and land-based rehabilitation programs are effective in improving functional mobility, pain, ROM, and quality of life in women with knee osteoporosis. However, the aquatic program demonstrated superior improvements in most variables, likely due to the unique physical properties of water that reduce joint stress and facilitate smoother, pain-free movement. These results support the integration of aquatic exercise as a primary or complementary rehabilitation approach for women with knee joint disorders.

9 — Conclusion

The findings of this study demonstrate that both aquatic and land-based rehabilitation programs are effective in improving functional mobility, reducing pain intensity, increasing range of motion, and enhancing quality of life in women with knee osteoporosis. However, the aquatic rehabilitation program produced superior improvements across most outcome measures, particularly in functional mobility, endurance, pain reduction, and overall quality of life.

These enhanced outcomes can be attributed to the unique physical properties of water—such as buoyancy, viscosity, and hydrostatic pressure—which reduce joint loading, facilitate smoother and pain-free movement, and allow participants to perform therapeutic exercises with greater confidence and comfort. In contrast, land-based training showed slightly greater gains in muscle strength, reflecting the benefits of weight-bearing and resistance-based exercises.

Overall, the study highlights the value of aquatic exercise as a safe, effective, and accessible therapeutic option for women with knee osteoporosis. Integrating aquatic rehabilitation into clinical practice may provide significant benefits, especially for individuals experiencing pain or difficulty performing land-based exercises. Combining aquatic and land-based training may offer an optimal rehabilitation strategy by leveraging the strengths of both modalities

10 — Recommendations, Limitations, and Future Research

Recommendations, Limitations, and Future Research

1. Clinical Recommendations

Based on the findings of this study, several practical recommendations can be made for clinicians, rehabilitation specialists, and healthcare providers:

• Aquatic rehabilitation should be considered a primary therapeutic option for women with knee osteoporosis, particularly in mild to moderate stages of the condition.

• Rehabilitation centers and physiotherapy clinics are encouraged to implement structured aquatic programs, as they have demonstrated superior outcomes in pain reduction, mobility enhancement, and functional performance.

• Combining aquatic and land-based training may provide optimal therapeutic benefits, leveraging the advantages of both modalities—pain-free movement in water and strength gains through land-based resistance exercises.

• Patients should be educated on the importance of regular therapeutic exercise to prevent functional decline, maintain joint health, and improve long-term quality of life.

• Aquatic exercise may be particularly beneficial for individuals with high pain levels, limited weight-bearing tolerance, or fear of movement.

2. Study Limitations

Despite the positive findings, this study has several limitations that should be considered when interpreting the results:

• The sample size was relatively small (n = 30), which may limit the generalizability of the findings to larger populations.

• The intervention period was limited to 8 weeks; longer rehabilitation programs may produce different or more sustained outcomes.

• Only women aged 45–60 years were included, restricting the applicability of the results to other age groups or to men.

• Muscle strength was not directly measured using advanced dynamometry, which could have provided more precise and objective strength data.

• The study did not include long-term follow-up, making it unclear whether the observed improvements are maintained over time.

3. Future Research Directions

To build on the findings of this study, future research should consider the following directions:

• Conduct larger randomized controlled trials comparing aquatic and land-based rehabilitation across different age groups and both genders.

• Investigate long-term effects of combined aquatic-and-land rehabilitation models, particularly programs lasting more than 12 weeks.

• Explore psychological and social benefits of aquatic exercise, including self-efficacy, fear of movement, motivation, and mental well-being.

• Examine the effectiveness of different types of aquatic programs, such as aquatic aerobics, resistance-based hydrotherapy, and thermal aquatic therapy.

• Utilize biomechanical and electromyographic assessments to better understand the mechanisms underlying improvements in mobility, strength, and pain reduction.

• Include follow-up assessments to determine the sustainability of improvements after the end of the intervention.

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