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Original Article

Aquatic vs. land-based exercise after arthroscopic partial meniscectomy in middle-aged active patients with a degenerative meniscal tear: A randomized, controlled study

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ABSTRACT

Background: Awareness of the value of aquatic exercise (AE) in the postoperative rehabilitation has increased, and several inherent advantages of AE, such as adjustment of both resistance and muscle strengthening parameters makes good rationale for its inclusion in postoperative rehabilitation. This study aimed to determine and compare the benefits of AE and land-based exercise (LBE) on pain, functionality, and quality of life after arthroscopic partial meniscectomy (APM).
Methods: This randomized controlled study included 30 middle-aged (35–50), physically active patients who were randomized into LBE (n = 15) and AE (n = 15) groups after APM for a degenerative meniscal tear. Visual analogue scale (VAS), Short Form-36 (SF-36), single-leg hop test and Lysholm questionnaire scores in addition to isokinetic muscle strength values were evaluated at baseline, at fourth week immediately after cessation of exercise program and at eighth week follow-up visits. The exercise sessions were conducted in 1-h sessions per day, three days a week for a total of four weeks.
Results: Significant improvement was observed in the VAS, single-leg hop test, Lysholm questionnaire, and most of SF-36 subscale scores in both groups at both fourth and eighth follow-ups. Isokinetic dynamometer revealed significant improvement in the peak torque values for extension at angular velocities of 60° and 180° at both follow-ups in the AE group. LBE group showed significant improvement in the peak torque value for extension only at an angular velocity of 60° only at fourth week follow-up. There was no significant difference between groups for any of these parameters at any of the follow-ups.
Conclusion: Both AE and LBE programs had significantly improved pain, function, isokinetic muscle strength, and quality of life in patients after APM. Either type of exercise is essential as part of the rehabilitation protocol for good clinical outcomes after APM and should not be neglected (level II).
ClinicalTrials registration number: NCT04925726.

1. Introduction

The term degenerative meniscal tear refers to a meniscal lesion that occurs without a significant history of acute trauma. This type of lesion typically occurs after the age of 35, and its prevalence increases in the elderly [1,2]. A degenerative meniscal tear can cause symptoms refractory to conservative treatment and have the potential to affect activities of daily living [1]. Arthroscopic partial meniscectomy (APM) has become the standard method in the management of complex degenerative meniscal tears that are not suitable for primary repair. It has been reported that APM has several advantages over other existing methods such as shorter hospital stay, lower complication rates, easier rehabilitation and better cost-effectiveness [3,4]. Nevertheless, previous studies report that patients frequently experience knee swelling, pain, and loss of range of motion (ROM) in the early postoperative period of APM [5]; hence, the vast majority of surgeons agree that proper postoperative rehabilitation of the knee is essential to return to an active lifestyle [6]. The goals of rehabilitation after APM are to reduce pain and swelling as much as possible and to achieve full weight bearing with maximum knee ROM [7].

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Today, awareness of the value of aquatic exercise (AE) in the rehabilitation of spine and extremity disorders has increased [8]. Sudden or damaging movements are prevented during AE by the resistance of water against movement, and at the same time, patients gain increased cardiovascular fitness, muscle strength, endurance and flexibility. Moreover, non-weight bearing AE is credited with stimulating quadriceps and hamstring strength, as well as improving aerobic endurance after meniscal injuries and arthroscopic meniscectomy. Indeed, these features make it appropriate and rational to include AE in post-APM rehabilitation. Researchers of this study hypothesized that AE could improve clinical outcomes after APM with regard to certain parameters such as pain, functionality, and quality of life.

To the best of our knowledge, there are no reported studies comparing the effectiveness of performing AE and land-based exercise (LBE) during postoperative rehabilitation in patients who have undergone APM for degenerative meniscal tear. This study aims to determine and compare the benefits of AE and LBE with objective outcome measures such as Visual Analogue Scale (VAS), single leg jump test, Lysholm questionnaire and Short Form-36 (SF-36) scores in addition to isokinetic dynamometer measurements after APM.

2. Materials and methods

2.1. Participants and study design

This randomized controlled trial was designed to evaluate and compare the clinical outcomes of AE and LBE programs in post-surgical rehabilitation of APM. The study included middle-aged and physically active patients undergoing APM for degenerative meniscal tear in the department of Orthopaedics and Traumatology. Both exercise programs were initiated on the 15th post-operative day, and standard post-surgical rehabilitation protocols were applied to all patients in this study, apart from these exercise programs.

The ethics committee of the university hospital approved the study protocol, and all of the participants provided written informed consent and written permission from their physician allowing their participation in the research. The inclusion criteria were as follows: a non-locked but painful knee of more than 1 month, clinical history and examination consistent with degenerative meniscus lesion, positive evidence of a degenerative meniscal tear visible with magnetic resonance imaging (MRI), no response to nonoperative treatment for at least 3 months after the onset of symptoms, no evidence of advanced osteoarthritis (OA) on X-rays or MRI and patients aged 35–50 years. Exclusion criteria included advanced knee OA, systemic inflammatory diseases, concurrent tear of anterior, posterior cruciate or collateral ligament, history of previous anterior, posterior cruciate or collateral ligament repair, problems that can cause radiating pain to the knee (e.g., hip and ankle pathologies), history of cardiopulmonary disease that could limit isokinetic and functional testing, unstable medical condition, serious cognitive deficit, psychiatric disorder, no capacity for independent walking and standing, an open wound on the skin, and pregnancy (Table 1).

2.2. Randomization

Patients who met the study criteria were randomly divided into two groups using numbered envelopes. The randomization process was carried out by a physician who did not contribute to the study.

2.3. Interventions

The first patient group performed LBE, and the second group performed AE. The exercise program was commenced on the 15th postoperative day in order to avoid problems in postoperative wound healing. On the other hand, patients were still advised to perform ROM exercises before commencing the exercise program.

2.4. LBE group (n = 15)

As part of a home-based program, patients were prescribed ROM exercises for the hips and knees, stretching and strengthening, lateral and forward lunges, squats, stair climbing, knee bends, heel raises, and leg stability. This home-based program was started on the 15th postoperative day and patients were instructed to perform these exercises in 1-h sessions per day, three days a week for a total of four weeks. A physiotherapist demonstrated the exercises to the patients once, and all the patients were given written guidelines describing the exercises.

2.5. AE group (n = 15)

This group of patients performed exercises under the supervision of a physiotherapist in a swimming pool with a water temperature of 33 °C in 1-h sessions per day, three days a week for a total of four weeks. The program comprised initial warm-up exercises by the pool for 15 min and subsequent joint ROM exercises for the hips and knees in the pool for 40 min, stretching and strengthening, walking in different directions, jumping and bicycle exercises, stair climbing, lunges, squats, and leg stability exercises. The program concluded with 5 min of cool down (slow walking, squatting, and standing).

2.6. Outcomes

The clinical outcome measures of the exercise programs were evaluated at baseline, at the fourth week follow-up immediately after the exercise program, and at the eighth week follow-up. Demographic characteristics of the patients were recorded before starting the exercise programs. Pain intensity, isokinetic muscle strength, quality of life, and function level measures were used in the evaluation.

2.7. Visual analogue scale (VAS)

VAS was used to assess pain intensity [9]. VAS scoring was performed at the time of patient's initial, fourth and eighth week follow-up visits. (0–10 cm, higher scores indicate more pain).

2.8. Assessment of isokinetic muscle strength

Isokinetic knee extensor muscle strength values of the patients were measured with an isokinetic dynamometer (IsoMed 2000; D&R Ferstl GmbH, Hemau, Germany). A standard warm up was performed for 15 min before the test. The patients were then seated in the dynamometer chair with 90° hip flexion in the vertical position. The trunk, pelvis, and thighs were securely strapped to the device allowing free movement of the knee. The patients were given the opportunity to try the test so that they could get used to the device and make the necessary movements. The test was repeated ten times at the velocity of 60°/second and 180°/second and peak torque (Nm) measurements were recorded [10].

Table 1
Inclusion and Exclusion criteria for the study.

Inclusion criteria	Exclusion criteria
1 A non-locked but painful knee of more than 1 month	1 Advanced knee OA
2 Between 35 and 50 years old	2 Systemic inflammatory disease
3 Clinical history and examination consistent with degenerative meniscus lesion	3 Concurrent tear of anterior, posterior cruciate or collateral ligament
4 Positive evidence of a degenerative meniscal tear visible with magnetic resonance imaging (MRI)	4 History of previous anterior, posterior cruciate or collateral ligament repair,
5 No response to nonoperative treatment for at least 3 months after the onset of symptoms	5 Problems that can cause radiating pain to the knee (e.g., hip and ankle pathologies)
6 No evidence of advanced osteoarthritis (OA) on X-rays or MRI	6 History of cardiopulmonary disease that could limit isokinetic and functional testing
	7 Unstable medical condition
	8 Serious cognitive deficit
	9 Psychiatric disorder
	10 No capacity for independent walking and standing
	11 An open wound on the skin
	12 Pregnancy

2.9. Health-related quality of life assessment (SF-36)

The physical and mental health summary scores were the primary components used. Scoring is on a scale of 0–100 and a higher score reflects better health-related quality of life [11].

2.10. Assessment of functionality

A single-leg hop test and the Lysholm questionnaire were used to evaluate functionality.

2.11. Single-leg hop test

The patient stands on one foot with the big toe touching a line marked on the floor. The participant asked to hop forward as far as possible using the same leg with their arms swing freely on both sides of the body. Distance is measured from the starting point to the heel of the landing leg [12].

2.12. Lysholm questionnaire

Eight subtitles are scored separately (limping or use of support: 5 points, locking sensation: 15 points, joint instability and pain: 25 points, swelling: 10 points, stair climbing: 10 points, and squatting: 5 points). The highest and optimal total score is 100 points [13].

2.13. Power of the study

Since there is no study in the literature exactly matching with our design and hypothesis, a preliminary study was conducted with 6 patients with groups. The power analysis, based on descriptive statistics of the pain score levels with mean and standard deviation values obtained from the preliminary study, demonstrated that a total number of 20 patients must be examined with each group containing at least 10 patients to identify the statistical significance of the time-related difference (Paired Sample T-test model effect size 1.3655) in pain scores (VAS) within each group under 95% power and 5% type 1 error conditions. The power analysis was conducted with G Power- 3.1.9.2 open source software.

2.14. Statistical analysis

IBM SPSS Statistics for Windows, Version 22.0 software (IBM Corp., Armonk, NY, USA) was used to perform the statistical analyses. The Kolmogorov–Smirnov test was used to test the normality of the distribution of the data. The intergroup differences of categorical variables were assessed using a chi-squared test. A sample t-test was used to compare means. Repeated measures analysis of variance was used to evaluate when the clinical assessment parameters were observed. The Bonferroni test was used as a post hoc test to determine the difference between groups. The significance level was set at $p < 0.05$ for all of the statistical analyses.

3. Results

3.1. Patient characteristics

A total of 30 patients were recruited for the study. Fig. 1 summarizes the patient recruitment, participation, and attrition during the research period. There was no significant difference in the demographic characteristics and evaluation parameters of the patients (Table 2). The mean age of the participants was 45.1 ± 5.4 years, and 66.7% were women.

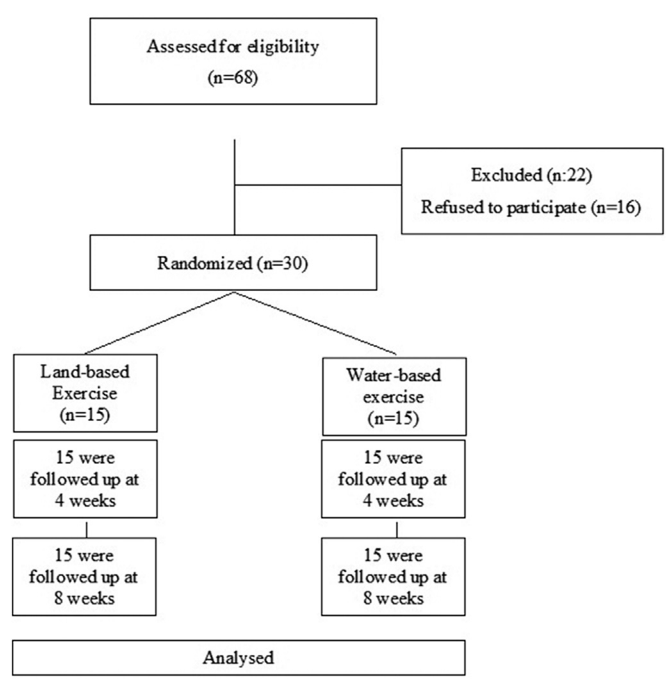

Fig. 1. Flow chart of the study.

Table 2
Baseline demographic and clinical characteristics of the patients.

Variables	LBE n:15	AE n:15	p value
Age, years (mean ± SD)	43.5 ± 5.6	46.8 ± 4.9	0.094
Sex, M/F (n)	6/9	4/11	0.700
Body Mass Index, kg/cm^2	25.5 ± 4.0	23.9 ± 3.8	0.439
Operated leg (right) (n)	6	8	0.464
Visual Analogue Scale (VAS), cm	5.3 ± 1.4	6.1 ± 0.9	0.148
Short Form-36			
Physical functioning	51.2 ± 16.4	46.4 ± 18.6	0.454
Physical role	31.9 ± 28.7	25.1 ± 21.3	0.870
Pain	34.2 ± 13.9	37.8 ± 11.5	0.305
General health	44.9 ± 7.2	44.4 ± 9.2	0.744
Vitality	47.5 ± 11.6	48.6 ± 7.9	0.412
Social functioning	50.3 ± 17.3	46.8 ± 13.8	0.624
Emotional role	42.5 ± 27.1	33.2 ± 17.7	0.305
Mental health	52.2 ± 13.0	50.9 ± 16.6	0.569
Lysholm knee score	55.3 ± 21.5	55.8 ± 11.3	0.941
Single leg hop test (cm)	14.0 ± 7.1	11.3 ± 4.8	0.243
Isokinetic quadriceps muscle strength (Nm/kg)			
60/sn	32.1 ± 21.9	21.6 ± 20.7	0.116
180/sn	15.1 ± 11.8	9.8 ± 9.8	0.081

Data were presented as mean ± SD or n (%). *p < 0.05.

3.2. Change in VAS

Table 3 provides details of the changes in pain intensity as seen before treatment and at the fourth and eighth week follow-up visits of patients who were randomly assigned to AE and LBE groups after APM. During follow-up, a significant improvement was observed in both groups ($p < 0.05$). There was no significant difference between groups during follow-up ($p > 0.05$).

3.3. Change in Lysholm score

Intra-group evaluations revealed that a significant improvement was observed in both groups without a significant difference between the exercise groups during follow-up ($p > 0.05$) (Table 3).

3.4. Change in single-leg hop test

A significant improvement was observed in both the AE and LBE groups at the fourth- and eighth-week follow-ups. No significant difference was recorded between groups ($p > 0.05$) (Table 3).

3.5. Change in isokinetic measurement results

In the AE group, a significant improvement was observed in the peak torque value for extension at an angular velocity of 60° and 180° at both the 4- and 8-week follow-ups. In the LBE group, a significant improvement was determined in the peak torque value for extension at an angular velocity of 60° only at the fourth week follow-up. However, no significant difference was recorded between groups at fourth or eighth week follow-up ($p > 0.05$) (Table 3).

3.6. Change in SF-36 score

Significant improvement was observed in the SF-36 subscales of each group at the fourth and eighth week follow-ups; however, no significant difference was noted between groups ($p > 0.05$) (Table 4).

No adverse events or discomfort were reported by patients during either exercise program or at follow-ups; in addition, patients stated that they had no difficulty in following the routine and were satisfied with the results.

Table 3
Comparison of mean VAS, Lysholm knee score, Single leg hop test, isokinetic quadriceps peak torque values of groups at baseline, at 4th week (immediately after exercise program) and at 8th Week.

	Land-based exercise	Aquatic exercise	p value
Visual Analogue Scale			
Baseline	5.3 ± 1.4	6.1 ± 0.9	
At 4th week	2.5 ± 1.7[a]	2.7 ± 1.3[a]	0.653
Mean differences	2.9	3.4	
95% CI	1.9 to 3.8	2.7 to 4.1	
At 8th week	1.1 ± 1.5[b]	1.3 ± 1.1[b]	0.233
Mean differences	4.3	4.7	
95% CI	3.2 to 5.4	3.9 to 5.6	
Lysholm knee score			
Baseline	55.3 ± 21.5	55.8 ± 11.3	
At 4th week	79.7 ± 11.9[a]	81.3 ± 13.3[a]	0.354
Mean differences	−24.3	−25.5	
95% CI	−34.4 to −14.3	−31.8 to −19.3	
At 8th week	94.3 ± 7.5[b]	94.6 ± 7.26	0.300
Mean differences	−38.9	−38.8	
95% CI	−51.8 to −26.1	−45.1 to −32.5	
Single leg hop test			
Baseline	14.0 ± 7.1	11.3 ± 4.8	
At 4th week	19.3 ± 9.1[a]	16.3 ± 6.8[a]	0.800
Mean differences	−5.3	−4.9	
95% CI	−8.5 to −2.2	−7.9 to −2.0	
At 8th week	23.7 ± 11.6[b]	19.8 ± 9.8[b]	0.969
Mean differences	−9.7	−8.5	
95% CI	−14.2 to −5.3	−13.2 to −3.8	
Isokinetic quadriceps peak torque 60 °/sec			
Baseline	32.1 ± 21.9	21.6 ± 20.7	
At 4th week	52.0 ± 31.5[a]	37.2 ± 29.0[a]	0.935
Mean differences	−19.9	−15.6	
95% CI	−39.6 to −0.2	−29.7 to −1.5	
At 8th week	52.9 ± 32.0	37.8 ± 21.0[b]	0.567
Mean differences	−20.9	−16.2	
95% CI	−44.3 to 2.6	−29.3 to −3.1	
Isokinetic quadriceps peak torque 180 °/sec			
Baseline	15.1 ± 11.8	9.8 ± 9.8	
At 4th week	32.0 ± 28.9	24.7 ± 22.6[a]	0.624
Mean differences	−16.9	−14.9	
95% CI	−38.3 to 4.4	−28.9 to −0.8	
At 8th week	32.3 ± 29.2	24.1 ± 20.2[b]	0.595
Mean differences	−17.2	−14.3	
95% CI	−37.9 to 3.5	−26.1 to −2.6	

* and ** for between group comparisons (*p < 0.01, **p < 0.05).
[a] Within group comparisons (Baseline- 4th week).
[b] Within group comparisons (Baseline-8th week).

4. Discussion

This present study compared the results of the four-week AE and LBE programs in patients who underwent APM surgery for degenerative meniscal tear. Results revealed that both AE and LBE programs significantly improved pain, function, isokinetic muscle strength, and quality of life in patients after APM; however, neither exercise program ultimately showed significant superiority over the other with regard to the parameters outlined above.

AE have been reported to relieve pain, reduce musculoskeletal stiffness, and promote muscle relaxation in individuals with arthritis, particularly in warm water [14]. Dündar et al. [15] reported that AE effectively relieved lumbar pain in patients with lumbar spine disorders. Wang et al. [16] also reported that AE can alleviate knee pain in patients with knee OA. These studies, which included different patient populations, also reported no significant difference in pain relief between AE and LBE.

Persistent pain after APM is a major problem since it can cause both quadriceps inhibition and limitation of ROM in the knee joint [2], and pain must be addressed promptly and effectively. Jokl et al. compared the efficacy of self-training at home vs supervised physical therapy in a study of 30 patients with APM, and reported

Table 4
SF-36 scoring among groups at baseline, at 4th week (immediately after exercise program) and at 8th week.

	Land-based exercise	Aquatic exercise	p value
SF-36, physical functioning			
Baseline	51.2 ± 16.4	46.4 ± 18.6	
At 4th week	63.8 ± 15.9[a]	55.9 ± 21.1[a]	0.910
Mean differences	−12.5	−9.5	
95% CI	−18.4± −6.6	−17.5± −1.4	
At 8th week	68.8 ± 16.5[b]	55.5 ± 20.8[b]	0.201
Mean differences	−17.5	−9.1	
95% CI	−22.4± −12.6	−14.5± −3.7	
SF-36, physical role			
Baseline	31.9 ± 28.7	25.1 ± 21.3	
At 4th week	59.8 ± 31.2[a]	39.6 ± 22.5[a]	0.151
Mean differences	−27.8	−14.5	
95% CI	−47.5± −8.2	−26.8± −2.2	
At 8th week	71.3 ± 36.2[b]	56.2 ± 30.7[b]	0.240
Mean differences	−39.3	−31.1	
95% CI	−68.2± −10.5	−58.7± −3.4	
SF-36, pain			
Baseline	34.2 ± 13.9	37.8 ± 11.5	
At 4th week	49.7 ± 14.8[a]	57.0 ± 23.1[a]	0.789
Mean differences	−15.5	−19.2	
95% CI	−30.9± −43.9	−36.9± −1.4	
At 8th week	64.3 ± 14.3[b]	76.6 ± 15.3[b]	0.875
Mean differences	−30.1	−38.8	
95% CI	−43.9± −16.2	−53.1± −24.5	
SF-36, general health			
Baseline	44.9 ± 7.2	44.4 ± 9.2	
At 4th week	49.9 ± 9.5	50.9 ± 9.5[a]	0.676
Mean differences	−4.9	−6.5	
95% CI	−13.1 ± 3.2	−12.6± −0.4	
At 8th week	50.5 ± 6.1	47.8 ± 9.8	0.302
Mean differences	−5.6	−3.4	
95% CI	−11.6 ± 0.5	−6.9 ± 0.1	
SF-36, vitality			
Baseline	47.5 ± 11.6	48.6 ± 7.9	
At 4th week	48.8 ± 6.9	50.9 ± 4.3	0.932
Mean differences	−1.3	−2.3	
95% CI	−8.9 ± 6.3	−8.3 ± 3.7	
At 8th week	51.9 ± 10.4	50.1 ± 7.5	0.507
Mean differences	−4.4	−1.4	
95% CI	−14.9 ± 6.3	−9.1 ± 6.2	
SF-36, social functioning			
Baseline	50.3 ± 17.3	46.8 ± 13.8	
At 4th week	62.4 ± 19.3	68.9 ± 23.7[a]	0.266
Mean differences	−12.2	−22.1	
95% CI	−26.3 ± 1.9	−37.6± −6.5	
At 8th week	68.2 ± 19.5[b]	59.9 ± 25.3	0.422
Mean differences	−17.9	−13.1	
95% CI	−33.4± −2.5	−28.7 ± 2.5	
SF-36, emotional role			
Baseline	42.5 ± 27.1	33.2 ± 17.7	
At 4th week	62.2 ± 29.3[a]	59.4 ± 33.6[a]	0.755
Mean differences	−19.8	−26.2	
95% CI	−36.9± −2.6	−50.6± −1.9	
At 8th week	71.8 ± 31.4[b]	60.5 ± 32.4[b]	0.646
Mean differences	−29.4	−27.2	
95% CI	−50.4± −8.4	−51.7± −2.7	
SF-36, mental health			
Baseline	52.2 ± 13.0	50.9 ± 16.6	
At 4th week	62.4 ± 11.7[a]	61.9 ± 12.9	0.442
Mean differences	−10.2	−11.0	
95% CI	−15.9± −4.6	−26.0 ± 4.0	
At 8th week	63.5 ± 13.1[b]	66.7 ± 16.1[b]	0.302
Mean differences	−11.3	−15.8	
95% CI	−18.5± −4.2	−30.2± −1.4	

SF-36: Short form- 36.
* and ** for between group comparisons (*p < 0.01, **p < 0.05).
[a] Within group comparisons (Baseline- 4th week).
[b] Within group comparisons (Baseline-8th week).

that both rehabilitation schemes were equally effective in terms of pain or functionality [17]. Furthermore, a study of 45 patients on post-APM rehabilitation programs randomized patients into three groups: home exercise only, home exercise with electromyographic biofeedback, and home exercise with electrical stimulation therapy to the quadriceps muscle. The authors reported a significant reduction in pain felt by the patients during walking in the second and sixth weeks postoperatively compared to the preoperative period in all groups. The same study reported that there was no significant difference in active knee extension measurements and pain intensity in the electrical stimulation group compared to the home exercise group [18]. Although these studies in the literature have examined patients with APM, none of them compared the clinical outcomes of AE with LBE.The results of this study suggest significant relief of pain in both exercise groups after APM ($p < 0.05$). On the other hand, there was no significant difference between the pain scores of the groups at both follow-up visits ($p > 0.05$).

Unlike other exercises, resistance and muscle strengthening parameters can be adjusted in AE. The reasons for these distinctive features in aquatic exercise can be explained as follows: (1) When the human body is in water, it has to apply force to eliminate surface tension, and the strength of the force is directly proportional to the body surface area in contact with the water, (2) water viscosity provides the resistance needed to improve muscle strength. In fact, these features make AE very suitable for a controlled muscle strength development program in postoperative patients. Several randomized, controlled studies have analyzed the effect of exercise after APM on muscle strength [19,20]. Jokl et al. [17] evaluated 30 APM patients with traumatic lesions who were allocated to a home exercise group ($n = 15$) or a supervised physiotherapy group ($n = 15$), and they have reported that unsupervised home exercise knee rehabilitation program can produce equally good post-operative recovery as compared to a supervised outpatient physical therapy regimen in properly selected patients following APM. The results of this present study indicated a significant improvement in isokinetic peak torque assessments at the angular velocity of both 60° and 180° at the fourth and eighth week follow-ups in AE group and at the fourth week follow-up in the LBE group. These results suggest that both types of exercise are effective in developing muscle strength without being superior to each other.

Although the type of exercise supervised in this study (AE) was different from that of Jokl et al. [17], they have reported similar conclusions about the effect of supervised vs. unsupervised exercise on muscle strength. Regarding the effect of supervised exercise on results, this study reports that properly performed unsupervised exercise can also effectively improve muscle strength in appropriately selected and compliant patients after APM.

Contrary to the results of this study, Lund et al. [21], Lim et al. [22], and Fisken et al. [23] did not report significant improvement in muscle strength after AE. Lund et al. [21] have reported a significant overall improvement in muscle strength for the LBE program compared with the control group, while a detrimental effect on muscle strength for AE compared with the control group at follow-up. Others found no difference between groups (AE, LBE, and control groups) in an isokinetic evaluation [22] or in handgrip strength in the group that performed AE [23]. These results may be associated with the selection of exercises, program progression, exercise intensity, or the tests used.

As noted by Ericsson et al. [24], isokinetic tests measure muscle strength; they do not assess other aspects of muscle function, such as coordination and timing. The authors added that functional performance tests, such as the single-leg hop test, replicate natural movements of sports or everyday life. Exercise programs used after APM are designed to improve functionality. This study used a single-leg hop test to assess the functional condition of the patients as well as Lysholm scoring to assess the knee function. The results suggest significant improvement in the groups in both parameters, however, there was no significant difference between the groups after the follow-up period. Similarly, a recent review evaluating the efficacy of hydrotherapy for patients with knee OA revealed no significant difference between AE and land exercise in terms of quality of life or physical function either immediately after the rehabilitation program or after the follow-up period [25].

Knee-related quality of life has been reported to decrease after APM [26,27]. There are very few studies investigating the effect of rehabilitation after APM on quality of life [28]. Goodwin et al. [28] compared the efficacy of a single home exercise program with a home exercise plus supervised physiotherapy program after APM in the short term and reported no significant difference between the groups in terms of any of the outcomes measured in a total of 84 patients. All recent studies investigating the effect of AE on quality of life included patients with OA [29,30]. A recently published Cochrane review found that an AE program had a limited, short-term, clinically relevant effect on patient reported quality of life in people with knee and hip OA [14]. On the other hand, the results of this study show a significant improvement in the quality of life of both patient groups according to the SF-36 scale. However, there was no significant difference between exercise groups.

A comprehensive review of the literature revealed that this is the first randomized controlled study to compare the clinical outcomes of postoperative AE versus LBE program in patients undergoing APM for degenerative meniscal tears. However, this study also has some limitations, such as the lack of supervision of the LBE group and the relatively short follow-up period. Therefore, this study was only able to evaluate the intermediate results of the patients. Moreover, changes in the duration and intensity of the exercise programs or the length of follow-up period could also affect the results. The fact that patients were not blinded in this study should be considered a limitation, although it is methodologically challenging in this type of study design since participants are instructed or supervised to perform certain types of exercise.

5. Conclusion

The present study revealed that both LBE and AE can improve pain, muscle strength, functionality, and quality of life in patients after APM, and the results suggest no significant difference between the outcomes of two exercise groups. Consistent with the authors' experience as well, LBE is known to be superior in terms of cost, time and space while AE is more recreational, socially motivating and a more suited choice in patients with limited weight bearing. In conclusion, the authors of this study would like to emphasize that it is critical to properly maintain an exercise program during rehabilitation after APM to achieve superior clinical outcomes.

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Ethical approval

Ege University Ethics Committee had approved the study protocol ((DN:18-7/59).

Informed consent

Informed consent was obtained from all individual participants included in the study.

Authors' contribution

All authors have made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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