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The Effect of Hydrotherapy on Motor Function Status, Pain, Kinesiophobia and Mood in Women with Knee Osteoarthritis

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Abstract

Background & Objectives: Although exercise is widely recommended as a first-line intervention for osteoarthritis (OA), the relative effectiveness of specific exercise modalities remains unclear. This study aimed to examine the effects of hydrotherapy on motor function and selected psychological health indicators in women diagnosed with knee osteoarthritis (KOA).

Materials & Methods: This quasi-experimental study employed a pre-test–post-test control group design and included 40 women with KOA (mean age = 56.5 years) who were selected through purposive sampling. Participants were assigned to either a hydrotherapy group (HG, n = 20) or a control group (CG, n = 20). The HG completed an eight-week hydrotherapy program based on the prescribed protocol, consisting of three 60-minute sessions per week. Outcome measures included the Osteoarthritis Research Society International (OARSI) physical function tests, the Visual Analogue Scale (VAS) for pain, the Tampa Scale of Kinesiophobia (TSK), and the 32-item Brunel Mood Scale (BRUMS). Data were analyzed using multivariate analysis of covariance (MANCOVA) in SPSS version 26, with statistical significance set at $p < 0.05$.

Results: Following the intervention, the HG demonstrated significant reductions in the durations of the Timed Up and Go (TUG) test (ES = 0.89), the 40-Meter Walk (40MW) test (ES = 0.91), and the Stair Climb Test (SCT) (ES = 0.33) ($p < 0.05$). Moreover, the HG showed marked reductions in pain ($F = 313.07$, $p = 0.002$, ES = 0.61), kinesiophobia ($F = 271.40$, $p = 0.001$, ES = 0.89), and mood disturbance ($F = 49.66$, $p = 0.001$, ES = 0.27).

Conclusion: Hydrotherapy significantly improved motor performance and psychological well-being in women with KOA. These findings support the integration of aquatic exercise as an effective therapeutic and preventive strategy for managing KOA.

Keywords: Hydrotherapy, Motor Function, Knee Osteoarthritis, Kinesiophobia

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Introduction

Osteoarthritis (OA) is the most prevalent progressive degenerative disorder of the musculoskeletal system worldwide. Although it can affect any synovial joint, it most commonly involves the hip and knee joints because of their substantial weight-bearing role, thereby affecting both proximal and distal function (1). Knee osteoarthritis (KOA) specifically refers to the gradual degeneration of articular cartilage in the knee joint and the subsequent deterioration of the underlying bony structures (2).

According to global epidemiological data, approximately 528 million individuals were

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affected by OA in 2019, representing a 113% increase compared with 1990. Notably, 73% of these individuals were aged 55 years and older, and women accounted for 60% of the affected population (3). This gender disparity is partly attributed to anatomical differences and hormonal fluctuations, particularly the decline in estrogen levels during menopause, which increases women's susceptibility to KOA (4). The initial clinical manifestation of KOA is typically joint pain, which alters gait patterns, leads to functional impairment, and reduces individuals' autonomy in performing daily activities. These limitations have a substantial impact on both physical and psychological well-being, ultimately diminishing overall quality of life. Furthermore, individuals with KOA frequently experience comorbid conditions such as cardiovascular disease, obesity, diabetes, hypertension, and depression, which compound the burden of disease and elevate it to a major public health concern (5).

Multiple risk factors contribute to the onset and progression of KOA, including advanced age, previous knee trauma, obesity, joint malalignment and instability, sedentary lifestyle, sex, comorbid diseases, genetic predisposition, and metabolic disorders (6). Clinically, OA is characterized by persistent joint pain, muscle weakness, episodic stiffness, instability, reduced functional capacity, and impaired quality of life (7). Despite its substantial individual and societal burden, there is currently no definitive cure or intervention capable of halting disease progression. Contemporary treatment strategies are therefore largely palliative, focusing on symptom relief through analgesic and anti-inflammatory medications (8).

In addition to impaired motor function, KOA is also associated with a range of psychological complications, particularly kinesiophobia and mood disturbances. Kinesiophobia is defined as an excessive, irrational, and debilitating fear of movement due to anticipated pain or reinjury. It is commonly observed in approximately 79% of individuals with musculoskeletal pain (9). In many cases, people with chronic pain develop an overwhelming fear that physical activity will aggravate their condition or cause further injury (10). This fear promotes avoidance of movement, contributing to physical deconditioning and the progression of chronic pain. Both fear-avoidance behaviors and kinesiophobia are regarded as major psychological factors in the development and maintenance of chronic musculoskeletal pain (11). When fear of movement is combined with negative behavioral responses, it often results in maladaptive avoidance patterns and adverse health outcomes, including prolonged physical inactivity. This cycle not only worsens physical function but also undermines overall well-being (12).

Mood, another psychological factor affected by OA, arises from emotional experience and may be understood as a set of sustained affective and cognitive states that shape individuals' perceptions, actions, and reactions (13). Mood states are typically broad, internally generated, and persistent, providing a contextual framework for ongoing experience (14). They are influenced by self-concept, personal goals, and value systems, all of which affect motivation, behavior, and interpretations of life events (15). Depending on age and the specific mood disorder, symptoms may range from depressive states with low mood to manic episodes marked by elevated mood (16). Unfortunately, because psychological disorders such as kinesiophobia and mood disturbances are broad and variable, no universally effective treatment is available. Although current interventions generally combine pharmacotherapy and psychotherapy, evidence suggests that adherence to clinical guidelines remains suboptimal. Moreover, these approaches often impose considerable financial and resource demands.

Given the high prevalence of KOA,

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particularly among women, there is an urgent need to identify and implement effective and sustainable treatment strategies. Surgical interventions and pharmacological treatments, although commonly prescribed, are often unsuitable because of their invasiveness, potential complications, high cost, and associated side effects (17).

Accordingly, the exploration of alternative, non-invasive treatment approaches is essential. One promising avenue is exercise and physical activity, which has attracted increasing scientific attention in recent years (18). Non-pharmacological interventions, including structured exercise programs, weight management, physiotherapy, and occupational therapy, are widely recommended as first-line treatments for OA. These approaches offer considerable benefits with minimal side effects. Nevertheless, despite their proven effectiveness and cost-efficiency, they remain underused in clinical practice (18).

Among the most suitable and effective therapeutic modalities for managing KOA is aquatic exercise. The unique physical properties of water, including hydrostatic pressure, buoyancy, and thermal effects, facilitate pain reduction and improve movement capacity in patients. These properties enable individuals to perform exercises in an aquatic environment that would otherwise be difficult or painful on land (19).

A growing body of evidence supports the efficacy of hydrotherapy in improving muscular strength and reducing joint stiffness around the knee in a non-weight-bearing setting (20). Moreover, buoyancy substantially decreases the gravitational load on the joints and muscles, making aquatic exercise particularly beneficial for specific populations such as individuals with obesity, older adults, postmenopausal women, and athletes recovering from injury (21).

In this regard, Noor et al. (2023), in a systematic review, reported that shallow-water exercise programs, including aerobic, stretching, strengthening, proprioceptive, and flexibility exercises conducted for 30 to 60 minutes per session, three times per week, over 4 to 12 weeks, improved KOA symptoms, balance, postural control, gait stability, and overall mobility (22). Similarly, Song and Oh (2022) confirmed that aquatic exercise effectively reduces pain and joint dysfunction, thereby improving quality of life in individuals with OA (23). These findings have been supported by other studies as well (24, 25). However, Wang et al. (2007) reported no significant effect of aquatic exercise on physical function or pain, suggesting that outcomes may vary depending on intervention design (26). Furthermore, there is currently no consensus regarding the optimal duration, frequency, or session length of aquatic therapy programs, indicating the need for further empirical investigation. In addition to physical benefits, recent studies have examined the role of exercise in mitigating psychological symptoms associated with OA, such as kinesiophobia and mood disorders (27). In a systematic review, Jadhakhan et al. (2023) found that physical activity interventions were effective in reducing kinesiophobia among individuals with chronic joint pain (28). Likewise, Su et al. (2021) and Hanel et al. (2020) reported that exercise interventions significantly reduced pain and symptoms of kinesiophobia (29, 30). Daily walking has also been shown to have a positive effect on mood states (31). However, the literature presents mixed findings, with some studies reporting increases in negative mood dimensions (32) and others reporting no significant changes in mood following physical activity (33).

Given the high prevalence of KOA among women, who constitute a vital demographic both socially and within the family structure, the disease poses multifaceted psychological, physical, therapeutic, and public health

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challenges. Accordingly, there is an urgent need to identify low-risk, feasible, and cost-effective treatment alternatives. Exercise-based interventions have long been recommended for both the prevention and management of KOA; however, relatively little research has focused specifically on aquatic exercise in this population.

Therefore, the present study aimed to examine the effects of hydrotherapy on motor function and selected health-related psychological indicators in women with KOA.

Methods and Materials

Study design and sample

The present study was a quasi-experimental, single-blind, applied investigation conducted in 2024 among women with KOA aged 50 to 60 years who were referred to Mahmoudieh, Hilal-Ahmar, and Sepehr clinics in Isfahan, Iran. After formal approval had been obtained from Isfahan University of Medical Sciences and the clinical sites had been visited, a rigorous participant selection process was initiated. Potential participants were identified through their medical records and their diagnosis was subsequently confirmed by a qualified orthopedic specialist. Individuals who met all predefined inclusion criteria and expressed voluntary willingness to participate were enrolled in the study.

Among the eligible patients, 40 women were selected through purposive sampling and allocated to two groups: a hydrotherapy group (HG, n = 20) and a control group (CG, n = 20). Although the target sample size was 40 to ensure adequate statistical power, operational constraints limited the number of participants who could be assigned to the experimental condition. Nevertheless, to uphold ethical standards and safeguard the right to care, the control group was offered the intervention after completion of the main study phase.

At the beginning of the study, participants were using analgesic and anti-inflammatory medications such as acetaminophen, ibuprofen, tolmetin, sulindac, indomethacin, fenoprofen, naproxen, celecoxib, diclofenac, and meloxicam, as well as certain strengthening agents. By the end of the study, they were generally using ibuprofen, naproxen, indomethacin, fenoprofen, acetaminophen, and some herbal analgesic and anti-inflammatory agents.

Based on calculations performed with G*Power software (version 3.1.9.2), the minimum required sample size was 36 participants (18 per group), with an alpha level of 5%, a statistical power of 80%, and an effect size of 0.30. However, to account for possible attrition at different stages of the study, 20 participants were assigned to each group.

Inclusion criteria

The inclusion criteria were as follows: women with KOA; women aged 50 to 60 years; written informed consent to participate in the study; no history of intra-articular injection of drugs or energy-boosting supplements; no participation in other training programs; ability to perform exercise, as determined on the basis of participants' medical records, the diagnosis confirmed by an orthopedic specialist, and the medical questionnaire; general good health; and ability to follow the training protocol.

Exclusion criteria

The exclusion criteria included absence from two consecutive training sessions, lack of proper cooperation during the intervention, injury, symptoms of hypotension during training, fear of water, and any condition incompatible with aquatic exercise, including skin diseases, hip or ankle OA, osteoporosis, or other joint diseases other than KOA.

Prior to the initiation of the training protocol, participants attended a detailed orientation session at the Hilal-Ahmar clinics. This session, held one week before the start of the program, covered the full protocol, potential benefits and risks, and the exact procedures

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required for exercise performance. In addition, participants received nutritional advice tailored to their physical activity levels. This guidance was provided consistently throughout the study period and was aligned with the standard medical care they were receiving.

Participants were also assured that their personal information would remain confidential and would be reported only in aggregate form. Furthermore, they were informed of their right to withdraw from the study at any stage if they no longer wished to continue. At the end of the orientation session, all participants were given the relevant forms to declare their willingness to participate voluntarily and knowingly in the study. The Ethics Committee of Islamic Azad University of Isfahan approved all stages of the research under ethics code IR.IAU.KHUISF.REC.1403.157.

After completing the medical questionnaire and providing informed consent, the participants were divided into two groups: hydrotherapy and control. The exercise protocol was implemented over 8 weeks, with three sessions per week. The control group did not receive the exercise protocol and continued its usual treatment regimen and daily activities. In both groups, height, weight, body mass index (BMI), motor function indices, and psychological variables were measured at two time points, pre-test and post-test. Participants were instructed to refrain from physical activity for 48 hours before testing, and their pre-test breakfast was kept consistent. Owing to time limitations, follow-up assessment was not feasible.

Instruments

Height was measured using a German caliper, SECA model 210, with an accuracy of 3 mm. Participants stood barefoot with their backs against a height-measuring tape attached to the wall. Their body weight was evenly distributed on both legs, with the head, trunk, and lower limbs aligned. The back of the legs, hips, and head touched the wall. A ruler was then placed on the participant's head to record height in centimeters while the participant exhaled.

Weight was measured using a digital scale, KEEP FIT Model 6657, manufactured in China. Participants stood on the scale wearing light clothing and no shoes, with their weight evenly distributed on both feet. Body weight was recorded to the nearest 0.1 kg. BMI was then calculated using the formula BMI = weight (kg) / [height (m)]^2, based on the measured height and weight values.

Method of assessing motor function indices

In this study, motor performance indices were assessed using the OARSI physical performance tests, which are designed to evaluate balance and functional status in older adults with OA.

Accordingly, the Timed Up and Go (TUG) test, the 30-second Chair Stand Test (CST-30), the Stair Climbing Test (SCT), the 40-meter Fast-Paced Walk Test (40m FPWT), and the 6-minute Walk Test (6MWT) were employed (34).

Tests procedure

The participant sat properly on a chair with armrests. A cone was placed on the floor 3 meters away from the chair. Upon the command to begin, the participant stood up, walked straight for 3 meters at a normal pace, turned, returned to the chair, and sat down. The stopwatch started with the command to begin and stopped when the participant was seated again. A shorter completion time indicated better performance.

30-Second Test of Up and Down (CST-30)

In this test, the participant sat down on and stood up from a chair 43 cm in height for 30 seconds, with both hands placed in front of the body on the chest. The number of complete sit-to-stand cycles performed within 30 seconds was recorded as the score.

Stair Climbing Test (SCT)

In this test, the participant stood at the bottom of a multilevel staircase consisting of 12 platforms, each 20 cm high, and, upon

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the command to begin, ascended the stairs as quickly as possible and then descended as quickly as possible. A stopwatch was used to record the total time. A longer completion time indicated greater activity limitation.

40-Meter Fast-Paced Walk Test (40m FPWT)

In this test, the participant completed a 10-meter route four times, bypassing the obstacles placed at the end of the route. Shorter completion time indicated better performance.

6-Minute Walk Test (MWT 6)

In this test, the participant walked for 6 minutes. The greater the distance covered, the better the participant's functional status.

These tests have high validity and reliability and have been recommended by the International Society for Osteoarthritis Research for assessing balance and functional status in older adults with this condition (7).

Method of assessing psychological indicators

Pain was assessed using a Visual Analogue Scale (VAS), which is one of the most widely used instruments in research for measuring pain intensity on the basis of self-report. The visual analogue scale for pain consists of a 10-cm line, with "no pain" marked at the left end and "most severe pain" at the right end. Participants indicated their perceived pain level during the previous 48 hours by marking a single point on the line. Pain intensity was then measured by the researcher using this standardized instrument. The scale is divided from 0 to 10 as follows: 0 to 1, no pain; 2 to 3, mild pain; 4 to 5, moderate pain; 6 to 7, severe pain; 8 to 9, very severe pain; and 10, unbearable pain. The VAS is widely used in epidemiological and clinical research to assess the severity or frequency of various symptoms. It also has high reliability and validity (35).

The Tampa Scale for Kinesiophobia (TSK) was used to assess kinesiophobia. This scale is the most commonly used instrument for measuring fear of movement related to pain and is suitable for use in populations with chronic pain (36). The TSK consists of 17 items, and participants responded to each item on a four-point Likert scale ranging from strongly disagree to strongly agree (37). When calculating the total score, the scores for items 4, 8, 12, and 16 were reverse coded, that is, 1 to 4 and 2 to 3, and vice versa. Because the total score is obtained by summing all item scores, the possible range of scores, with a minimum of 1 and a maximum of 4 for each of the 17 items, is 17 to 68, with higher scores indicating greater fear of movement and pain (38). The Persian version of the Tampa Scale for Kinesiophobia has acceptable validity and reliability, with a test-retest coefficient of 0.83 and an internal consistency coefficient of 0.82, for measuring fear of movement or injury in Iranian patients with chronic pain. It can therefore be used in clinical settings, treatment centers, and research contexts (39).

The Brunel Mood Scale, 32-item version, was used to assess mood. This scale includes eight subscales for measuring the positive and negative dimensions of individuals' mood states. Each subscale contains four items, which are rated on a five-point Likert-type scale: not at all (0), a little (1), moderately (2), quite a lot (3), and extremely (4). The first response option indicates the absence of the relevant mood state, whereas subsequent options reflect increasing intensity. Accordingly, the minimum possible score on the mood state questionnaire is 0 and the maximum possible score is 128. Higher scores indicate greater intensity in the measured mood state. In this questionnaire, vitality, calmness, and happiness, which comprise 12 items in total, are assessed as positive mood dimensions, whereas tension, depression, anger, fatigue, and confusion, which comprise 20 items in total, are assessed as negative mood dimensions (40). The Persian version of this questionnaire showed an internal consistency of 0.87 and a test-retest reliability of 0.88, indicating satisfactory validity and reliability (41).

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Hydrotherapy Protocol

Hydrotherapy exercises were performed for eight weeks, three sessions per week, with each session lasting approximately 60 minutes. All stages of the training program were carried out under the supervision of a sports medicine specialist at the Iranian Health Clinic. The program was conducted between 9:00 a.m. and 11:00 a.m. The exercises were performed in a standard swimming pool maintained at a temperature of 32 to 34°C.

To reduce the risk of potential knee joint injury and to enhance mobility in the affected joints, a 10- to 15-minute warm-up and cool-down period was performed at the beginning and end of each session. The exercises were organized into six one-week phases in order to follow the principle of variety and to ensure a gradual increase in exercise load and intensity (42) (Table 1). The hydrotherapy program included moderate-intensity strength, endurance, balance, and stretching exercises recommended by the American Geriatrics Society (43). Notably, all participants completed the intervention program.

Statistical Analysis

To analyze the data, descriptive statistics were used to calculate measures of central tendency and dispersion, with the results reported as means and standard deviations. The Shapiro–Wilk test was applied to assess the normality of the data, and Levene's test was used to examine the homogeneity of variances. To determine whether there were significant differences in the group means between the pre-test and post-test phases, multivariate analysis of covariance (MANCOVA) was performed using SPSS version 26, with the level of significance set at 0.05.

Results

The mean and standard deviation of the participants' age, height, weight, and BMI are presented in Table 2. No significant differences were observed between the two groups in age, height, weight, or BMI ($p \geq 0.05$).

Table 3 shows that, following hydrotherapy, the completion times for the TUG, 40MW, and SCT tests decreased significantly in the training group ($P = 0.001$). In addition, the hydrotherapy group showed significant increases in the scores of the 30-S-CS and 6MWT tests ($P = 0.001$).

Table 1. Hydrotherapy Exercises.

Stage	The water depth	Lower extremity exercise	Set for each leg
1	Sternum Xiphoid process	Two-legged squats, rising on toes of both feet, dynamic lunge, standing on one leg and extension/flexion, extension/flexion of the knee of the other leg	2×10
2	Anterior superior iliac spine	Standing on one leg and abduction/adduction, abduction/adduction of the hip joint of the other leg, standing on one leg and Hip Hitch joint of the other leg	2×10
3	Anterior superior iliac spine	Standing on one leg and abduction/adduction, abduction/adduction of the hip of the other leg, standing on one leg and Hip Hitch of the other leg, dynamic lunge, single-leg squat, rising on one toe	2×10
4	Anterior superior iliac spine	Stage 3 exercises	2×10
5	Anterior superior iliac spine	Stage 3 exercises	2×10
6	Anterior superior iliac spine	Stage 3 exercises	2×10

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Table 2. Characteristics of research subject.

Variable	Hydrotherapy group (n = 20)	Control group (n = 20)	p-Value
Age (year)	56.5±6.4	56.2±3.27	0.43
High (cm)	161.2±5.81	161.4±4.26	0.65
Weight (kg)	75.4±4.7	75.2±7.04	0.6
BMI (kg/m2)	29.00±5.2	28.92±3.8	0.78

Values are reported as mean±SD; BMI: body mass index

Table 3. Comparison of motor function tests for hydrotherapy and control groups between pre- and post- test in women with KOA.

Variable	Groups	Pre-Test	Post-Test	P-value	F	ES
TUG	HG	13.62±1.12	10.61±1.27	0.001ʎ	41.75	0/89
	CG	12.8±1.21	12.29±1.1	0.92		
30-S-CS	HG	7.2±1.2	9.53±0.99	0.002ʎ	18.9	0/27
	CG	7.20±1.18	7.53±1.34	0.87		
SCT	HG	39.2±5.92	34.06±6.85	0.002ʎ	57.14	0/33
	CG	40.06±6.18	39.33±6.38	0.98		
40MW	HG	73.07±8.22	52.97±7.9	0.002ʎ	15.18	0/97
	CG	72.64±7.67	71.37±6.92	0.72		
6MWT	HG	517.33±45.18	578.33±58.12	0.001ʎ	91.81	0/76
	CG	521.66±71.3	522.66±54.49	0.6		

ʎ: significant differences from pre-test to post-test; *: significant difference between two groups. Values are reported as mean±SD; Significant difference at P≤0.05; F: statistical value MANCOVA; TUG: Timed Up and Go Test; 30-S-CS: 30-Second Test of Up and Down; SCT: Stair Climbing Test; 40MW: 40-meter Fast Paced Walk Test; 6MWT: 6-Minute Walk Test; HG; Hydrotherapy Group; CG: Control Group.

Table 4. Comparison of pain, kinesiophobia, and mood for hydrotherapy and control groups between pre- and post- test in women with KOA.

Variable	Groups	Pre-Test	Post-Test	P-value	F	ES
Pain (mm)	HG	6.37±0.89	4.32±1.2	0.011ʎ	29.76	0/89
	CG	6.17±0.52	6.18±1. 2	0.63		
Kinesiophobia	HG	46. 66±7.54	29.07±7.95	0.001ʎ	271.84	0/27
	CG	46.20±12.04	44.93±11.71	0.92		
Mood	HG	75. 54±10.84	57.13±11.91	0.002ʎ	49.66	0/33
	CG	75.33±7.63	74.66±7. 88	0.87		

ʎ: significant differences from pre-test to post-test; *: significant difference between two groups. Values are reported as mean±SD; Significant difference at P≤0.05; F: statistical value MANCOVA; HG; Hydrotherapy Group; CG: Control Group

Based on the data in Table 4, after the intervention in the hydrotherapy group, the levels of pain, kinesiophobia, and mood decreased significantly (P=0.001).

Discussion

The findings of the present study indicated that aquatic exercise significantly improved motor function outcomes in women with KOA. In addition, significant reductions in pain and kinesiophobia, as well as improvements in mood, were observed.

Previous studies have consistently shown that regular exercise interventions improve physical and motor function indices in individuals with KOA. For example, Etesami, Dholaktaf, and Esmaili (2022) compared the effects of eight weeks of land-based and aquatic

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exercise therapy on functional activities in older women with KOA. Their findings showed that both exercise modalities had equally favorable effects on functional performance (44). Similarly, Xu et al. (2024) reported a negative association between different types of physical activity and the incidence of KOA, suggesting that higher levels of physical activity may be protective (45).

In a related study, Wang et al. (2023) identified sedentary behaviors, such as prolonged television viewing, as causal risk factors for KOA and spinal OA (27). Noor et al. (2023), in a systematic review, reported that although aquatic exercise protocols varied considerably in terms of method, duration, and frequency, most studies demonstrated significant improvements in balance, postural control, and mobility in individuals with KOA (22). Likewise, Khruakhorn and Chiwarakranon (2021) showed that both aquatic and land-based exercise interventions led to significant improvements in Timed Up and Go (TUG), Sit-to-Stand (STS), and Stair Climb Test (SCT) outcomes after six weeks of training and six months of follow-up (25).

Conversely, findings have not always been consistent. Erfanian Zorufi et al. reported no significant improvement in static balance between the experimental and control groups after eight weeks of resistance training with elastic bands (46). By contrast, Bavardi Moghadam et al. observed significant differences in functional performance indices, including stair climbing, 30-second sit-to-stand, and 8-foot walk, between groups receiving theraband resistance training and aquatic exercise, with the aquatic approach yielding superior results (47).

Because pain, muscle weakness, and impaired physical function form a self-reinforcing cycle in KOA, in which muscle weakness contributes to pain and functional limitation and thereby accelerates disease progression, muscle-strengthening exercises are of particular therapeutic importance. In this regard, Bennell et al. (2020) found that strength training was more effective than aerobic exercise in alleviating short-term impairments such as pain, whereas aerobic training provided greater benefits for long-term functional outcomes (48). In contrast, Brosseau et al. (2003) concluded that aerobic exercise is generally more beneficial than no exercise and is either superior to or comparable with strength training for patients with OA (49). Although no universal consensus has yet been reached regarding the most effective exercise modality for the treatment of KOA, current evidence supports the short-term benefits of both resistance and aerobic training in improving muscle strength and physical function in individuals with mild to moderate KOA. While various forms of exercise appear to produce comparable analgesic effects, they differ in their impact on functional outcomes. This underscores the importance of individualized exercise therapy rather than the application of uniform protocols to all patients. Robust evidence indicates that, when physical activity and exercise are prescribed appropriately in terms of frequency, intensity, and duration, they often yield superior outcomes to pharmacological, injection-based, or surgical treatments (50).

Among the available exercise options, aquatic exercise stands out as both effective and enjoyable, with unique properties that make it particularly suitable for resistance training and rehabilitation (51).

Given these advantages, hydrotherapy may be recommended as an effective intervention for improving physical performance and functional capacity in individuals with KOA. It may be used either as a standalone therapy or in combination with other non-pharmacological and pharmacological interventions, such as land-based exercise, manual therapy, knee braces, and physical modalities, including

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transcutaneous electrical nerve stimulation (TENS), thermotherapy, and ultrasound.

The results of the present study further confirmed that aquatic exercise significantly reduced pain and kinesiophobia and improved mood in women with KOA. These findings are consistent with prior research highlighting the psychological and functional benefits of aquatic interventions in the management of OA. For example, Henriksen et al. (2024), in a systematic review, emphasized that exercise remains the primary strategy for managing KOA-related pain (52). Similarly, Mo et al. (2023) found that aquatic exercise, resistance training, stationary cycling, traditional forms of exercise, and yoga all significantly improve KOA symptoms, with aquatic exercise being particularly effective for pain relief and yoga proving more beneficial for joint stiffness, limited function, and quality of life (53).

In another review, Xuan et al. (2023) reported that aquatic training reduced pain and improved muscle strength in patients with KOA (54). Consistent with these findings, Ma et al. (2022) also reported that aquatic physiotherapy and exercise were associated with significant reductions in pain indices among individuals with KOA (55).

Overall, the findings of the present study, together with previous evidence, indicate that water-based exercise has a meaningful effect on pain relief in individuals with OA. The buoyant properties of water reduce weight-bearing stress on the joints, thereby enabling more comfortable and functional movement. The principal physical properties of water that contribute to its therapeutic benefits include buoyancy, hydrostatic pressure, and resistance. Hydrostatic pressure facilitates blood circulation, helps alleviate muscle spasms, and reduces fatigue, whereas water resistance provides gentle opposition to movement, thereby enhancing muscle strength. Buoyancy, by reducing the gravitational load on the joints, bones, and muscles, enables patients to perform weight-bearing activities without excessive strain or pain (56).

A significant reduction in kinesiophobia was also observed following aquatic exercise in the present study. These findings are consistent with those of Jadhakhan et al. (2023), who reviewed the effects of physical activity on kinesiophobia in individuals with chronic pain. Their results confirmed that exercise interventions effectively reduce fear-avoidance behaviors in such populations (28). Similarly, Su et al. (2021) demonstrated that a 12-week exercise intervention significantly reduced pain and kinesiophobia in a retired athlete (29). Balci et al. (2020) also reported beneficial effects of both land-based and water-based exercise on kinesiophobia in individuals with chronic pain (12). Additional evidence from Galan-Martin et al. (2020) (57) and Hanel et al. (2020) (30) further supports these findings.

Aquatic exercise offers a particularly safe and effective approach to reducing kinesiophobia because of its low-impact movements, controlled breathing patterns, and relaxing environment (58). Water provides approximately ten times the resistance of air, thereby increasing muscular engagement, particularly in older adults. This greater resistance stimulates the motor cortex, improves motor unit synchronization, and enhances motor neuron excitability. Consequently, increased muscle strength and functional independence may contribute to reductions in fear of movement (59). In addition, the physical properties of water, including surface contact, buoyancy, and the sensory experience of immersion, may help alleviate kinesiophobia and promote a sense of safety and connection with nature (60).

Furthermore, the results of this study indicated notable improvements in mood among women with KOA following aquatic exercise. These findings are consistent with those of Sakuragi and Sugiyama (2006), who

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found that daily walking improved mental symptoms, mood, and neurological function in individuals with general physical complaints (31). Although some studies have reported no significant change (33) or even increased negative affect depending on variables such as exercise intensity and duration (32), most research supports the view that regular moderate-intensity exercise produces positive mood changes, particularly when it is perceived as enjoyable and satisfying. In the present study, moderate-intensity aquatic exercise appeared to elicit similar mood-related benefits. These effects are likely linked to neurobiological mechanisms, as physical activity stimulates the release of endorphins, which are associated with increased pleasure, reduced stress, and lower anxiety.

This study also had several limitations that should be considered when interpreting and generalizing the findings. The intervention lasted 8 weeks and did not include a follow-up phase; a longer intervention period with follow-up would likely have provided a more robust evaluation of the sustained effects. Although participants were strongly advised to maintain their usual diet and sleep patterns and to avoid physical activity outside the study program, these variables were not under the researcher's direct and precise control. In addition, the same exercise program was administered to all participants, whereas individualized programs tailored to each participant's characteristics may have yielded more effective results.

Given these limitations, future research should extend the intervention period and incorporate follow-up assessments to examine the stability and persistence of the intervention effects. Moreover, because dietary habits, sleep quality and duration, and physical activity outside the research setting were not precisely controlled, these factors should be monitored and managed more systematically in future studies. Furthermore, since the same exercise protocol was applied to all participants, individualized training programs adapted to each participant's characteristics and needs may help produce more accurate and effective outcomes. In addition, studies involving larger and more diverse samples, together with more precise measurement instruments, may strengthen the validity of the findings and improve their generalizability.

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Conflict of Interest

The authors report no conflict of interest.

Code of Ethics

This study was approved by the Islamic Azad University of Isfahan (No. IR.IAU.KHUISF.REC.1403.157).

Authors' Contributions

All authors equally contributed to this study.

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