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Aquatic Physical Therapy in the Rehabilitation of Athletic Injuries: A Systematic Review of the Literatures

Eunkuk Kim* **and Hokyung Choi**

Department of Physical Education, Korea National Sport University, Seoul, Republic of Korea

Abstract

This review aimed to analyze the evidence of the effects of aquatic physical therapy in athletes and persons who participate in sports activities. Pertinent databases were searched from the beginning of databases until June 2015 to determine the effectiveness of aquatic physical therapy in the rehabilitation of sports injuries in athletes and/or individual who enjoy sports activities. A total of 311 articles were identified. Eight articles met the inclusion criteria, and the average methodological quality on the Physiotherapy Evidence Database (PEDro) scale was 7. Aquatic physical therapy in the rehabilitation of sports injuries improved pain, range of motion, muscle strength, balance ability, and performance, but the evidence regarding benefits of aquatic physical therapy compared to land-based physical therapy was inconclusive. Further investigation is therefore needed to clarify this.

Keywords: Aquatic physical therapy; Rehabilitation; Athlete

Introduction

Athletes engage in several sporting events and activities. The masters-level athletes, especially, compete for well over 50-60% of their lifetime. Because athletes these days are training harder, competing more often, and taking lesser time for recovery, they are likely to suffer from sports injuries such as sprain, tendinopathy, bursitis, and stress fractures [1,2]. The incidence rate of ankle sprain, one of the most common sports injuries, is 7 per 1,000 exposures or 1.37 per 1,000 athletes and 4.9 per 1,000 hours [3]. Despite these sports injuries, athletes are expected to return to sport-specific training as soon as and as intensively as possible. Especially, in the case of masters-level athletes, it is a fact that the athletes' leading desire is to return to competition or training as soon as possible [4].

Rehabilitation for sports injuries may include transitory rest and discontinued training [2]. For example, the sprained ankle leads to the athlete resting for an average of 1-3 weeks, with no participation in competitions or training [5]. Several previous studies have shown that 3 weeks of inactivity can lead to a significant loss of cardiovascular fitness, and 6 weeks of rest can lead to a decrease of as much as 14-16% of maximal oxygen consumption [6-8]. Additionally, Kim et al. reported that stress to affect collagen fibers in injured ligaments through functional rehabilitation helps with accurate alignment of the collagen fibers [9]. Because of these reasons, rehabilitation of athletes is initiated as quickly as possible, while respecting the constraints of healing [9]. In their study, Bleakley et al. showed that exercise during the first week after sustaining an ankle sprain improved ankle function, which supports early rehabilitation [10].

The aquatic environment is ideal for early rehabilitation of injuries due to buoyancy, which decreases the effects of gravity on the body, and viscosity, which offers assistance or resistance [11]. Performing joint movements in water provides limb support and allows range of motion, without excessive muscle activation, and this allows a transition to more advanced dynamic strengthening or conditioning exercises on dry land [12]. Konlian reported that aquatic physical therapy helps athletes return to exercise early and speeds up the overall rehabilitation process [11]. Furthermore, Thein and Brody insisted that many athletes have found utilization of a water-based program during their active rest period of recovery to be beneficial in regaining mobility and, strength, and maintaining or improving cardiovascular endurance, while resting the injured area [2].

The aim of this systematic review was to synthesize the available literature on aquatic physical therapy, analyze evidence of the effects of aquatic physical therapy in athletes and individuals who enjoy sports activities, and provide information on the rehabilitation of athletes and individuals with sports injuries. It is hoped that physical therapists and/or sports practitioners will use this information based evidence for relieving symptoms associated with sports injuries in athletes and other individuals.

Materials and Methods

Criteria for this review

Studies that were conducted to determine the effects of aquatic physical therapy intervention in the rehabilitation of sports injuries were considered for this review. The outcomes included pain, range of motion, muscle strength, balance ability and performance. E inclusion criteria were: (1) Diagnosis of musculoskeletal dysfunction such as low back pain, ankle instability, knee ligament sprain, or no health problems; (2) Athletes or individuals who enjoy sports activities; (3) Use of aquatic therapy as an intervention; (3) No previous surgery in the area of the lesion; and (4) No other serious comorbid conditions such as fracture in lesion, rheumatic disease, neurological disease.

Search strategy and data extraction

For this review, published studies on aquatic physical therapy intervention for rehabilitation of sports injuries were searched for, according to the search strategy of Dickersin et al. [13]. An extensive

***Corresponding author:** Eunkuk Kim, Department of Physical Education, Korea National Sport University, Korea, Tel: 82-2-410-6830; Fax: 82-2-410-6719; E-mail: lkimg@knsu.ac.kr

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search of pertinent databases including Medline, CINAHL, Cochrane Database of Systematic Reviews, BioMed Central, ProQuest Health and Medical Complete from the beginning of the databases until June 2015 to identify studies on rehabilitation or physical therapy interventions, using the following keywords: ("aquatic physical therapy" OR "aquatic physiotherapy" OR "hydrotherapy" OR "aquatic rehabilitation") AND ("sports injury" OR "athletic injury"). The article selection of articles for this review was based on screening of titles and abstracts of publications found in the database by reviewers. If the reviewers identified an article as one that met the inclusion criteria, or if there was inadequate information to make a decision, a copy of the article was obtained. Data including population, intervention, outcome assessment, data analysis, follow-up and key results were evaluated by reviewers to confirm eligibility and determine the effects of aquatic physical therapy or rehabilitation on sports injuries.

Assessment of the validity of the study

The methodological quality of each article was reviewed using the Physiotherapy Evidence Database (PEDro) scale [14]. The PEDro scale consists of 11 questions (Table 1). These questions are scored as either yes (1 point) or no (0 points). The total PEDro scores have been shown to be reliable [14]. An article with a score of 7 is considered to have a high methodological quality; one with a score of 5-6 is considered to be of moderate methodological quality; and one with a score between 0 and 4 is regarded as having a poor methodological quality [15].

Results

The literature search resulted in a total of 311 (37 Medline, 67 CINAHL, 78 Cochrane Database of Systematic Reviews, 45 BioMed Central, and 84 ProQuest Health and Medical Complete) published articles that were screened. After the initial screening of abstracts, 48 were excluded as duplicates, and 255 were excluded for not meeting the inclusion criteria (49 did not involve musculoskeletal dysfunction; 67 did not involve athletes or individuals who enjoy sports activities; and, 139 involved other serious comorbid conditions), resulting in 8 aquatic physical therapy studies that met the inclusion criteria and were included in this review. A summary of these 8 studies is presented in (Table 2).

Methodological quality of the studies

The methodological quality of the studies ranged from 5-10 on the PEDro scale of internal validity (Table 3) with a mean score of 7. Four articles were of high quality, and 4 were of moderate quality.

Outcome measures

Pain: Pain was assessed in 2 articles [9,16] using the Visual analogue scale (VAS), which was the most commonly used tool [17], whereas Robinson et al. [18] evaluated pain sensitivity using a pressure gauge, the algometer. Dundar et al. [16] showed a statistically significant reduction in the level of pain at rest, during movement, and at night in 32 patients suffering from low back pain after participation in an aquatic exercise program, 5 times a week for 4 weeks, but there was no significant interaction between groups by time. Furthermore, Kim et al. [9] found that there were significant group by time interactions. In other words, the line graph for VAS in the aquatic exercise group showed a more rapid change than that in the land-based exercise group. Robinson et al. [18] showed that there was no significant interaction for pain sensitivity, or significant difference in pain sensitivity, between the land and aquatic groups, but in each group, there was a significant increase in the perception of pain sensitivity.

Range of motion: Range of motion was measured in only 1 article [16]. Dundar et al. [16] demonstrated in lumbar flexion, extension, and right and left rotation in 32 patients suffering from low back pain after participation in an aquatic exercise program, 5 times a week for 4 weeks, but there was no significant interaction between the aquatic and land-based groups by time.

Muscle strength: Isokinetic muscle strength was evaluated as eccentric and/or concentric peak torque in 2 articles [18,19]. Robinson et al. [18] revealed that there were significant increases from pre-training to mid-training, and from mid-training to post-training for eccentric and concentric peak torques of flexion and extension in 16 women who exercised regularly after performing aquatic plyometric exercise for 8 weeks, but there were no treatment by time interactions. Martel et al. [19] showed significant differences in the concentric peak torque of either the dominant or non-dominant leg in both the aquatic plyometric training group and control group when comparing baseline values with those obtained after 6 weeks. Specifically, the concentric peak torque of the dominant leg in the aquatic plyometric training group displayed significantly larger increases than the control group for knee extension at 180°/s.

Balance ability: Static and/or dynamic balance ability was measured in 3 articles [9,12,20]. Kim et al. [9] showed significant decreases in the overall stability index including medial/lateral and anterior/posterior static stability at 2 and 4 weeks after a 3-week functional rehabilitation program in both the aquatic and land-based group, but there was no significant difference between groups and no significant group by time interaction. Additionally, the test completion time for dynamic

PEDro question	Answer
Eligibility criteria were specified	Yes/No
Subjects were randomly allocated to groups	Yes/No
Allocation was concealed	Yes/No
The groups were similar at baseline regarding the most important prognostic indicators	Yes/No
There was blinding of all subjects	Yes/No
There was blinding of all therapists who administered the therapy	Yes/No
There was blinding of all assessors who measured at least one key outcome	Yes/No
Measurements of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	Yes/No
All subjects for whom outcome measurements were available received the treatment or control condition as allocated, or where this was not the case, data for at least one key outcome were analyzed by intent to treat	Yes/No
The results of between-group statistical comparisons are reported for at least one key outcome	Yes/No
The study provides both point measurements of variability for at least one key outcome	Yes/No

Table 1: Physiotherapy Evidence Database (PEDro).

	Design	N (% female)	Mean age(SD) in years	Intervention /Training	Outcome measures	Assessment/ Follow-up	Results
Robinson et al. [18]	Repeated measures	32 (100)	20.2 (0.3)	Plyometric training in water or on land (3 days a week for 8 weeks)	Sargent vertical jump test Peak torque 40 m sprint Self-report ordinal scale(muscle soreness) Pain sensitivity	Pre-training Mid-training (4 weeks) Post-training (8 weeks)	There were no treatment by time interactions, indicating that there were no performance and pain sensitivity differences between the land- and aquatic-trained groups (p>0.05). There was a significant interaction of treatment group by time for perception of muscle soreness (p=0.01).
Martel et al. [19]	Repeated measures	19 (100)	15(1)/14(1) (aquatic group/ control group)	Plyometric training in aqua or on land (twice a week for 6 weeks)	Vertical jump Isokinetic peak torque	Baseline After 2 weeks After 4 weeks After 6 weeks	There were significant increases in vertical jump after 4 weeks and 6 weeks in both groups (p<0.05). Significant improvements in concentric peak torque were observed in the dominant leg of both groups after 6 weeks (p<0.05).
Roth et al. [20]	Repeated measures	27 (62)	21.18 (1.24) /22.43 (1.81) (female/male)	Balance training program in aqua or on land (for 4 weeks)	X and Y range of Single leg stance (SL), Tandem, stance (T), and Single leg foam stance (SLF) Tandem form stance (TF)	Pretest Mid-test (2 weeks) Post-test (4 weeks) Follow-up test (6 weeks)	A significant group * time interaction for the X range was found for SL, SLF, and TF (p<0.05). The Y range improved significantly, with posttest value lower than pretest value (p<0.05).
Stemm and Jacobson [22]	Pre-test / Post-test	21 (unknown)	24 (2.5)	Plyometric training in aqua or on land (twice a week for 6 weeks)	VERTEC vertical jump test	Pre-test Post-test	Aquatic and land-based groups significantly outperformed the control group in the vertical jump, but no significant difference was found in the vertical jump between the aquatic and land-based groups.
Dundar et al. [16]	Randomized controlled trial	65 (47)	35.3 (7.8)/34.8 (8.3) (aquatic /land-based)	Exercise program in aqua or on land (5 times a week for 4 weeks)	Spinal range of motion Schober test Visual analogue scale for pain Oswestry low back pain disability questionnaire Short-form 36 health survey for quality of life	Before the treatment After the treatment (after 4 weeks and 12 weeks)	Statistically significant improvements were detected in all outcome measures except the Schober test compared with baseline (p<0.05).
Kim et al [9]	Randomized controlled trial	22 (27)	26 (4.1) /26 (3.1) (aquatic /land-based)	Early functional rehabilitation program in aqua or on land (5 sessions per week for 3 weeks)	Visual analogue scale for pain Static stability Dynamic stability Percentage single-limb support time	Baseline After 2 weeks After 4 weeks	Both groups showed decrease in the visual analogue scale, static and dynamic stability, and percentage single-limb support time at 2 and 4 weeks (p<0.05). There were significant group by time interactions for the visual analogue scale, static and dynamic stability, and percentage single-limb support time (p<0.05).
Asimenia et al. [21]	Pretest / Posttest	30 (46)	20.58 (0.64)	Balance program in aqua or on land (3 times per week for 6 weeks)	Total anterior-posterior and medial-lateral stability for static stability Dynamic stability test	Before the program After the program	In both groups, balance ability of the injured leg was significantly improved after the training period (p<0.05). In the final measurements, no statistically significant differences were found between the injured and non-injured.
Nualon et al. [23]	Repeated measures	47 (8)	20.79 (1.89) /20.04 (1.22) (hydro/land-based)	Functional rehabilitation program in aqua or on land (twice a week for 6 weeks)	Single-limb hopping test Ankle joint position sense	Baseline After 6 weeks After 3 months	In the hydrotherapy group, the time taken for the single-limb hopping test decreased significantly immediately after exercise and at follow-up compared with the base line (p=0.001). In the land-based group, time taken for the single-limb hopping test decreased significantly at follow up compared with baseline (p=0.05). No significant differences were detected between groups in the ankle joint position sense (p>0.05).

Table 2: Summary of 8 articles of aquatic physical therapy interventions: design, intervention, outcome, assessment, and results.

stability in both groups showed significant decreases at 2 and 4 weeks, and there was a significant group by time interaction. Roth et al. [12] reported that the aquatic group had a significantly smaller range of medial-lateral value than the land group and the control group after balance training for 4 weeks, and there was a significant condition by time interaction. In addition, there was a significant time and condition effect for the range of anterior-posterior values. Asimenia et al. [20] showed that 6-week balance training programs improved all balance performance indicators including total stability index, anterior-posterior index, medial-lateral index, and targets in both aquatic and land groups, but there was no significant group by time interaction.

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Article	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Total score (/11)
Robinson et al. [18]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	7/11 high quality
Martel et al. [19]	Y	N	N	Y	N	N	N	Y	Y	Y	Y	6/11 moderate quality
Roth et al. [20]	Y	N	N	Y	N	N	N	Y	Y	Y	Y	6/11 moderate quality
Stemm and Jacobson [22]	Y	N	N	Y	N	N	N	Y	Y	Y	N	5/11 moderate quality
Dundar et al. [16]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	10/11 high quality
Kim et al. [9]	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	9/11 high quality
Asimenia et al. [21]	Y	N	N	Y	N	N	N	Y	Y	Y	Y	6/11 moderate quality
Nualon et al. [23]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	7/11 high quality

Table 3: Methodological quality using the Physiotherapy Evidence Database (PEDro) scale.

Performance: Performance was evaluated as variables including vertical jump, 40-m sprint velocity, single-limb support time, and single limb hopping test in 5 articles [9,18,19,21,22]. Robinson et al. [18] showed significant increases from pre-training to mid-training and from mid-training to post-training for peak vertical jump and 40-m sprint velocity with an 8-week plyometric training program, but there was no treatment by time interaction. Martel et al. [19] reported significant increases in vertical jump after 4 weeks and 6 weeks in both the aquatic plyometric training and control group after a 6-week plyometric training program; however, the aquatic plyometric training group improved from 4 weeks to 6 weeks, whereas there was no significant improvement in the control group. Stemm and Jacobson [21] reported that in the vertical jump, the aquatic and land-based groups significantly outperformed the control group after a 6-week plyometric exercise program, but there was no significant difference between the aquatic and land-based groups. Kim et al. [9] revealed that the single-limb support time in both aquatic and land-based groups increased significantly at 2 and 4 weeks, but there was no significant difference between groups. Additionally, there was a significant group by time interaction. Nualon et al. [22] showed that the single-limb hopping test for ankle functional ability in the hydrotherapy group was significantly different between pretest and posttest and between pretest and the follow-up test. In the land-based group, there was a significant difference only between pretest and the follow up test. However, there was no statistical difference between the groups, and there was no significant group by time interaction.

Discussion

The objective of this systematic review was to evaluate the evidence for the effectiveness of aquatic physical therapy in the treatment of athletes and/or individuals with sports injuries. Our findings suggest that athletes and/or individuals who underwent aquatic physical therapy for rehabilitation of sports injuries showed improvement in pain, range of motion, muscle strength, balance ability, and performance. However, the evidence for the benefits of aquatic physical therapy in comparison to land-based physical therapy was found to be inconclusive.

The PEDro scores of all articles in this review ranged from 5 to 10, which correspond with moderate to high quality, and the average score was 7, which is considered as moderate methodological quality. However, all articles in this review had a methodological weakness in that it was difficult to generalize their results to athletes and/or individuals with sports injuries.

The 8 articles included subjects with a variety of sports injuries such as ankle instability, low back pain, and knee ligament injury and those with no health problems [9,12,16,18-22]. They underwent different types of aquatic exercise programs including the plyometric, balance training, and functional rehabilitation programs, and they were evaluated using various method. Therefore, we were unable to determine the ideal aquatic physical therapy program from this review, which is needed during rehabilitation of a specific sports injury to derive clinically significant benefits. A possible explanation for this might be that each article was designed with a specific sports injury, specific goals, and different primary outcome measures.

Water has a calming counterirritant effect, and it desensitizes the individual from pain because sensory input from the water pressure and temperature may decrease the pain sensation [11,16]. Among the various available instruments, the 10 cm VAS was used most commonly for measuring pain intensity [17]. In this review, Kim et al. [9] and Dundar et al. [16] found that the aquatic exercise program relieved pain, as measured by VAS. However, Kim et al. [9] insisted that the VAS in the aquatic exercise group showed a more rapid change than that in the land-based exercise group, whereas Dundar et al. [16] reported no significant interaction between groups by time. Further studies are needed to determine if aquatic physical therapy is more effective for pain relief compared to land-based therapy.

Buoyancy enables greater range of movement via supporting the body weight, and decreases the effective weight of an individual in proportion to the degree of immersion [23,24]. When standing in chest-deep water, the weight-bearing load is approximately 40% of the total body weight, whereas stepping in waist-deep water increases the weight-bearing value to approximately 60% [24]. Therefore axial loading on the spine and weight-bearing joints, particularly the hip, knee, and ankle, is reduced with increasing depths of immersion [24]. Using this principle, restricted glenohumeral and periscapular shoulder motion following injury, which needs early active range of motion for restoration of normal shoulder kinematics and return of shoulder function, can be treated in water to promote both active and passive movement in the early stages of rehabilitation [24,25]. A previous study insisted that aquatic physical therapy has been suggested as a method to improve active shoulder motion in an environment that does not adversely stress the injured or surgically repaired tissues [12]. However, in this review, only 1 article measured the lumbar flexion, extension, and right and left rotation range of motion after an aquatic exercise program; however, but there was no significant interaction between the aquatic and land-based groups by time[16]. For determining effectiveness and safety of aquatic exercise compared with land-based exercise, further studies are needed.

Changing the water depth allows for progression of resistance, and warm water increases muscle efficiency [23]. A previous study showed that the lower extremity strength deficit during the course of aquatic therapy treatment following anterior cruciate ligament surgery was 21.9% at 12 weeks post-surgery and, 7.9% at 20 weeks post-surgery compared to the strength of the non-operated lower extremity [26]. In this review, both articles demonstrated increase in muscle strength after training in water or on land, but there was interaction of aquatic and land-based groups by time, except in the case of some of the measured values.

Aquatic physical activity enhances coordination, while stimulating visual, vestibular, and perceptual systems [16]. When using water for lower limb training including standing in the water and maintaining a stable upright stance over the base of support, although aquatic training provides a non-weight-bearing condition for the joints, water movement and turbulence play an important role by overloading the postural control systems especially during one-leg stance [27]. In this review, 3 articles showed that the ability to maintain static and dynamic balance increased after aquatic and land-based training, but the results of comparing aquatic training with land-based were inconsistent.

Plyometric training is a popular method used by athletes to increase power and explosiveness [22]. However, Grantham warns that plyometrics, if not executed in a controlled environment, can potentially produce or exacerbate an injury and suggests that plyometric training in a pool may boost muscle strength while reducing impact forces [28]. Three articles in this review showed that the peak vertical jump after plyometric training in water or on land improved regardless of the environment, but there were no differences within groups[18,19,22]. However, one article reported muscle soreness after the first week of training and when the training intensity was increased was smaller in aquatic plyometric training compared to land-based training [18]. This result may support the argument that aquatic training is safer than land-based training.

A high recurrence rate of ankle sprain has been reported in athletes who have residual symptoms such as pain, swelling, weakness, and instability, and this occurrence of multiple episodes of ankle sprain and instability is referred to as chronic ankle instability [23]. One of the articles in this review showed that the functional ability of the ankle had improved after hydrotherapy until 3-month follow-up, and only 4 (17%) of 24 athletes who performed hydrotherapy reinjured their ankle, whereas 8 (35%) of 23 athletes who participated in land-based therapy reinjured their ankle [23]. Follow-up studies on the recurrence rate of sports injuries based on the environment in which the physical therapy is provided are needed for determining the effectiveness of aquatic physical therapy.

This review has several limitations. First, the review focused only on articles published in English; it is, therefore, possible that potentially relevant articles published in other languages were missed. Second, some of the articles did not provide detailed information on data analysis. This may have affected the conclusions drawn from these articles; caution is therefore required in the interpretation of their findings. Third, this review included only 2 randomized controlled trails. Therefore, future studies should assess the value of gray literature and case-controlled studies to evaluate the benefits of aquatic physical therapy in the rehabilitation of specific sports injuries.

Conclusion

There is some evidence to suggest that aquatic physical therapy reduces pain and improves range of motion, balance ability, and performance of athletes and/or individuals who enjoy sports activities with/without sports injuries. However, it is difficult to determine whether aquatic physical therapy is more effective and safe than land-based therapy. Therefore, further investigation is needed to provide evidence of the benefits of aquatic physical therapy in rehabilitation of sports injuries, and should include a rigorous design, as in double-blind, randomized controlled trail, standardized measurement tools, and sufficient follow-up to determine the recurrence rate for sports injuries.

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