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Original Article

PRP platelet-rich plasma injection combined with aquatic exercise therapy improves functional recovery of basketball players with knee joint injury

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Abstract: Objective: To explore the effect of PRP platelet-rich plasma injection combined with aquatic exercise therapy on the functional recovery of basketball players with knee joint injury. Methods: This retrospective study included 60 basketball players who sustained knee joint injury between January 2021 to June 2023. Among them, 28 patients received PRP platelet-rich plasma injection (control group), while the other 32 patients received PRP platelet-rich plasma injection combined with aquatic exercise therapy (observation group). We compared the improvements in knee joint pain level, knee joint mobility, knee joint muscle strength and other indexes between the two groups before and after the interventions. Results: After 8 weeks of intervention, the visual analogue scale (VAS) score in the observation group was significantly lower than that before the intervention; Besides, the knee flexion range and Lysholm knee function score in the observation group were significantly improved (all P<0.05); and all these improvements were more substantial than those in the control group (all P<0.05). The KOOS scores of both groups increased significantly after 8 weeks of intervention as compared to pre-intervention, and the scores in the observation group were significantly higher than those in the control group (all P<0.05). Conclusion: PRP injection combined with aquatic exercise therapy significantly improves knee mobility, muscle strength and function, and reduces pain severity, in basketball players with knee injuries.

Keywords: Aquatic exercise therapy, PRP platelet-rich plasma injection, functional recovery, knee joint injury, basketball players

Introduction

Basketball is a popular sport worldwide. The intense and dynamic nature of the game predisposes basketball players to various degrees of knee injuries during training and competition. These injuries, often caused by high-intensity and frequent training, are among the most common and severe sports-related injuries, potentially jeopardizing athletes' sports career [1]. After kn7ee injury, traditional rehabilitation means, such as weight-bearing exercises and leg raising training, are widely used; however, these approaches lack standardized quantitative measures and can be arbitrary in application [2]. Moreover, athletes undergoing land-based rehabilitation for knee injuries frequently experience significant swelling and pain, which affects the recovery of the knee joint function [3].

Platelet-rich plasma (PRP) is a concentrated form of platelets obtained by centrifugation of whole blood. Upon activation, PRP releases a variety of bioactive substances that promote the tissue repair and regeneration, offering an effective treatment for knee osteoarthritis [4]. However, current research shows that RPR injection is prone side effects and limitations similar to the traditional treatment methods, failing to fundamentally repair the injured knee joint. Improper treatment can also lead to various adverse outcomes for the patient's prognosis [5, 6]. Therefore, seeking new rehabilitation treatment is crucial for effectively managing knee injuries in athletes.

Aquatic exercise therapy refers to a rehabilitation by utilizing the characteristics of water, such as temperature, buoyancy, viscous resistance and hydrostatic pressure, to facilitate tar-

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geted rehabilitation exercise in the water, thereby enhancing the functional recovery of patients [7]. Compared with land-based exercise rehabilitation, this form of therapy offers unique advantages, including promoting muscle relaxation, enhancing joint mobility, accelerating blood circulation, and improving muscle strength and endurance to prevent muscle atrophy; and improving body balance and stability [8]. It has been shown that aquatic exercise therapy is superior to traditional rehabilitation across various patient groups, including those with neurological, orthopedic conditions, and burns [9]. Additionally, it is effective in enhancing trunk motor function, alleviating bodily discomfort, and improving cardiorespiratory endurance [10]. However, there is a paucity of reports on the efficacy of aquatic exercise therapy in the rehabilitation of knee injuries in athletes.

Therefore, this study explored the efficacy of PRP injection combined with aquatic exercise therapy in treating knee ligament or meniscus injuries in basketball players, hoping to provide more basis for developing rehabilitation strategies for knee injuries.

Methods and materials

Study population

In this retrospective study, a total of 60 basketball players with Knee Joint Injury between January 2021 and June 2023 were included. The patients were divided into two groups based on their treatment modalities. The observation group (n=52 cases) received PRP injection combined with aquatic exercise therapy, while the control group (n=48 cases) received PRP injection only. The study was approved by the Ethics Committee of International College, Krirk University.

Inclusion and exclusion criteria

Inclusion criteria: 1) Basketball players with clinically diagnosed knee injuries (via imaging or laboratory tests); 2) Age ≥ 18 years; 3) Non-acute stage injury; 4) Diagnosed with knee ligament injuries or meniscus injuries of Grade I-II; 5) No other comorbid injuries; 6) Stable condition, suitable for sports rehabilitation; 7) Complete clinical data.

Exclusion criteria: 1) Presence of major comorbid conditions, such as cardiovascular or lung diseases; 2) Age <18 years old; 3) Injury in acute stage; 4) Presence of other combined injuries; 5) Contraindications to aquatic therapy, such as infectious diseases or open wounds; 6) Psychological aversions, such as aquaphobia.

Methods

The control group received PRP injection alone. PRP was injected once every two weeks, for a total of 4 sessions. Each session involved the extraction of 40 ml venous blood from the elbow under sterile conditions. According to the instructions, 7.5 ml PRP was prepared by using the Sichuan Nightingale ngl-xcf3000 blood component separator and then injected into the affected knee joint. Immediate local compression was applied for 3 minutes after each injection to prevent bleeding. After 10 minutes of each injection, patients performed 10 sets of flexion and extension of the affected knee joint to facilitate even distribution of the PRP within the joint.

The observation group received PRP injection combined with aquatic exercise therapy. The method of PRP platelet-rich plasma injection was the same as that of the control group. Aquatic exercise rehabilitation was structured into three phases. ① Adaptation Phase: This initial phase focused on early mobility and recovery of basic motor functions. Activities included enhancing joint mobility, strengthening muscles (quadriceps, hamstrings, etc.), and practicing walking exercises. ② Improvement Phase: The second phase was aimed at building basic strength and proprioceptive recovery. The objectives were to restore normal force lines and control over basic activities like independent walking, lunging, squatting, and single-leg balancing. This phase also emphasized strengthening the lower extremity and core, and transitioning from static to dynamic proprioceptive exercises. ③ Maintenance Phase: The final stage of therapy aimed to progress from functional strengthening exercises on a uniaxial plane to those on a multiaxial plane, alongside enhancing motor skills. Exercises included multi-directional landing controls, such as jumping up and turning and single-leg multi-directional jumps, and functional move-

Table 1. Comparison of clinical data between the two groups

Clinical parameters	Observation group (n=52)	Control group (n=48)	t/χ^2	*P*
Age (years)	36.8±6.1	39.4±3.9	4.847	0.251
BMI (kg/m^2)	21.3±9.8	21.3±5.7	2.078	0.122
Sex			4.49	0.43
Male (n, %)	36 (69.2%)	41 (85.4%)		
Female (n, %)	16 (30.8%)	7 (14.6%)		
Smoking (n, %)	29 (55.8%)	12 (23.1%)	5.283	0.032
Alcohol consumption (n, %)	19 (36.5%)	20 (41.7%)	0.084	0.772
Diabetes (n, %)	27 (51.9%)	12 (23.1%)	4.831	0.018
Affected limb (n, %)			1.234	0.085
Left	16 (30.8%)	14 (29.2%)		
Right	36 (69.2%)	34 (70.8%)		

ments like multi-directional strides, side strides, and stomping steps, supplemented by core strength exercises. The period lasted 8 weeks, 3 times per week, for a total of 24 experimental interventions for the observation group.

Observation indicators

Knee joint mobility was measured using a joint mobility measuring tape. Knee muscle strength was measured using the Multi-Joint Isokinetic Training and Testing System produced by Yikang Company. The protocol included slow (60°/s×5 repetitions) and fast (180°/s×15 repetitions) tests in centripetal mode. Tests were performed first at a slow speed (60°/s), followed by a fast speed (180°/s) with 1-min intervals between speeds and 5-minute intervals between testing each knee. Key metrics included knee flexor-extensor peak torque (PT) and knee flexor-extensor ratio (H/Q). The Lysholm knee score [10] was used to evaluate the knee joint function of patients across eight dimensions: limping, squatting, support, stair climbing, pain, instability, locking, and swelling. The total score was 100 points, with 95-100 indicating excellent function, 84-94 good, 65-83 fair, and below 65 points poor. The Knee Injury and Osteoarthritis Outcome Score (KOOS) measures knee injury impact, with higher scores representing better knee function [11]. Pain level was tested using the Visual Analog Score (VAS) scale, a subjective assessment where higher score represents greater pain level. The scale noted for its high reliability and validity, ranging from 0.71 to 0.99, with validity scores from 0.71 to 0.78 [12].

Statistical analysis

Data were processed and analyzed using SPSS 25.0 software. The results were expressed as mean ± standard deviation. The intra-group differences before and after the intervention were analyzed using the paired-sample t-test, and the inter-group differences between groups were analyzed using the independent-sample t-test. Count data were expressed as percentage (%) and analyzed using the chi-squared test. P<0.05 was considered statistically significant.

Results

Clinical characteristics

Table 1 presents the characteristics of all subjects involved in the study, totaling 100 basketball players with knee joint injuries. In the observation group, there were 16 limbs affected on the left side and 36 affected on the right side. The control group had 14 limbs affected on the left side and 34 affected on the right side. Statistical analysis revealed no significant differences between the two groups in terms of age, body mass index (BMI), sex, smoking history, alcohol consumption, affected limb, or presence of diabetes (all P>0.05).

Knee joint flexion

The knee flexion range in the observation group improved by 8.59° from baseline after 8-week intervention (P<0.05), while that in the control group was 8.06° (P<0.05) (**Table 2**). These findings suggest that an 8-week regimen of PRP injection combined with aquatic exercise effectively enhanced the range of knee flexion and joint mobility in patients.

Table 2. Comparison of knee joint flexion range between the two groups

Group	Before intervention	After intervention	t	*P*
Observation group (n=52)	98.88±3.98	108.65±2.21	8.673	0.021
Control group (n=48)	100.23±2.76	105.37±0.87	1.873	0.315

Table 3. Comparison of Lysholm knee function score between the two groups

	Control group (n=48)	Observation group (n=52)	t	*P*
Before intervention	69.23±5.98	69.97±3.02	2.697	0.102
Post-operative 2 weeks	69.34±6.01	72.12±2.99	2.984	0.095
Post-operative 4 weeks	69.98±6.94	72.67±2.76	0.084	0.772
Post-operative 6 weeks	70.87±6.12	73.65±2.04	0.099	0.674
Post-operative 8 weeks	71.43±5.98	79.01±1.98	5.283	0.032

Table 4. Comparison of KOOS function scores between the two groups

Index	Time points	Observation group (n=52)	Control group (n=48)	t	*P*
Symptom	Before intervention	54.92±6.90	52.92±4.86	1.673	0.348
	After intervention	69.89±3.81	53.95±3.01	9.263	0.004
	t	10.218	3.216	-	-
	P	0.001	0.058	-	-
Pain	Before intervention	49.23±6.03	50.33±4.34	1.873	0.315
	After intervention	63.91±3.99	57.03±4.18	12.943	0.002
	t	14.128	3.416	-	-
	P	0.001	0.062	-	-
Sports and entertainment abilities	Before intervention	47.23±8.02	52.82±3.82	0.785	0.332
	After intervention	54.72±4.97	57.53±2.97	11.194	0.031
	t	14.628	4.116	-	-
	P	0.001	0.076	-	-
Quality of life	Before intervention	43.01±9.43	46.1±16.4	0.685	0.432
	After intervention	47.92±2.76	48.62±2.85	7.194	0.041
	t	8.628	1.116	-	-
	P	0.011	0.073	-	-
Daily living activity	Before intervention	53.87±7.34	53.98±4.87	1.992	0.189
	After intervention	58.73±3.81	54.76±3.86	8.235	0.008
	t	14.318	3.216	-	-
	P	0.001	0.057	-	-

Note: KOOS: Knee Injury and Osteoarthritis Outcome Score.

Lysholm knee function score

The Lysholm knee function score in the observation group was obviously better than the control group after eight weeks' intervention (P=0.032) (**Table 3**).

KOOS function scores

As shown in **Table 4**, the observation group showed better improvements in symptom and pain relief, sports and entertainment abilities, quality of life, and daily living activities after eight weeks intervention, compared with the control group (all P<0.05).

VAS score

The VAS scores of the patients in the observation group were significantly lower than those of the control group after 8-weeks intervention (all P<0.05) (**Figure 1**).

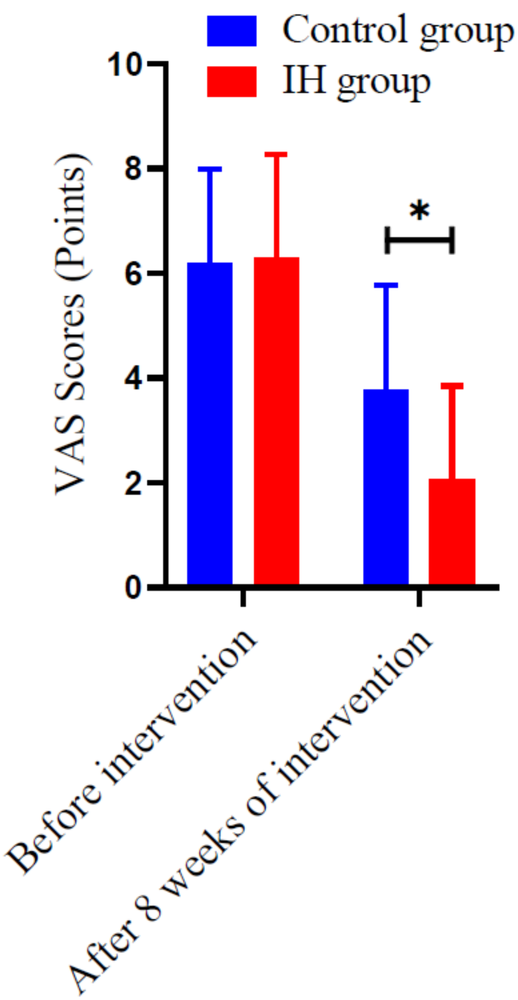

Figure 1. Comparison of VAS score between the two groups. **P<0.05*, compare with control group. VAS: visual analogue scale.

Balance ability

After intervention, the observation group demonstrated significantly higher balance ability than the control group (all P<0.05) (**Table 5**).

Discussion

Our data supported the initial hypotheses, demonstrating that the 8-week aquatic rehabilitation combined with platelet-rich plasma (PRP) injection significantly improved knee mobility, muscle strength, function scores, and reduced pain in basketball players with knee joint injury.

The present investigation highlights that PRP injection combined with aquatic exercise offers more significant benefits than PRP platelet-rich plasma injection alone, not only in alleviating pain, but also in functional restoration of the knee joint, which was consistent with current studies [13, 14]. In 2008, Sánchez et al. [15] conducted a comparative study involving 50 patients who received PRP therapy and anther 50 patients treated with hyaluronic acid injection, and concluded that the PRP injections were superior in pain management and improving fun-ctional activities. The synergistic effect of PRP injection and aquatic exercise is evident in several ways. The growth factors in PRP promote tissue repair and regeneration, while aquatic exercises help strengthen muscles and improve joint function [16-19]. A series of walking movements developed by the aquatic group helps both active and antagonist muscles, thus improving muscle strength and reducing muscle tension at the same time. Furthermore, stretching exercises performed in water can accelerate blood circulation in the knee joint, promoting muscle relaxation and recovery. These factors are crucial for enhancing knee joint mobility [20]. The combination of PRP injection and aquatic exercise is an effective treatment approach for improving knee function in patients with knee osteoarthritis, as it promotes tissue repair, reduces inflammation, strengthens muscles, and enhances overall joint function.

Significant improvement in pain score was observed in the observation group, aligning with findings observed in studies on patients after total knee and hip replacement [21, 22]. Platelet-rich plasma (PRP) injection combined with aquatic exercise has been shown to be an effective treatment for knee joint pain [23-25]. The reason for this is that PRP contains a high concentration of platelets, which are rich in growth factors that promote tissue healing and regeneration. When injected into the affected area, these growth factors stimulate the body's natural healing process, mitigating inflammation and pain [26]. Aquatic exercise offers distinct advantages for managing knee joint pain by providing a low-impact environment that allows for gentle movement and strengthening of the muscles surrounding the joint, which in turn enhances joint stability and functionality, reducing pain and improving mobility [27]. The combination of PRP injection and aquatic exercise works synergistically to address the underlying causes of knee joint pain. The growth fac-

Table 5. Comparison of balance ability between the two groups

Group	Before intervention	After intervention	t	*P*
Observation group (n=52)	29.65±12.76	35.76±9.98	9.892	0.009
Control group (n=48)	28.08±10.01	30.32±9.83	3.218	0.052
t	3.377	9.874	-	-
P	0.760	0.002	-	-

tors in PRP help to repair damaged tissue, while aquatic exercise helps to strengthen the muscles and improve joint function. This dual approach not only provides immediate pain relief but also promotes long-term healing and recovery.

Our findings suggests that PRP injection combined with aquatic exercise programs is helpful for improving balance ability among basketball players with knee joint injury. Another study reported that aquatic exercise training using water resistance equipment improved balance and walking ability among elderly individuals [28], which is similar with our study. Water provides a low-impact environment for exercise, reducing the strain on the knees compared to land-based activities. PRP has anti-inflammatory properties that can help reduce swelling and pain in the knee joint. By mitigating inflammation, the athletes experience less discomfort and can engage in water-based exercises more effectively, leading to improved balance [29]. Aquatic exercise challenge the body's balance and proprioception, requiring the players to constantly adjust and stabilize their movements. This type of training can help improve neuromuscular control and coordination, leading to better balance and reduced risk of falls or injuries [30]. The combination of PRP injection and water-based exercise can synergistically enhance the healing process, reduce inflammation, strengthen supporting muscles, and improve neuromuscular control, ultimately leading to improved balance in basketball players with knee joint injuries.

There are a few limitations to this study. Firstly, it lacks long-term follow-up, which is necessary to determine the durability of the observed effects over time. Secondly, the study is constrained by its design as a single-center and retrospective analysis with some geographic selectivity. These limitations highlight areas for further research and are the focus of our upcoming studies.

In conclusion, PRP injection combined with aquatic exercise can significantly accelerate the recovery of knee joint function in people with knee injuries, notably outpacing traditional land-based rehabilitation, thus shortening the rehabilitation process and helping basketball players with knee joint injuries regain their daily living abilities and return to work more swiftly.

Disclosure of conflict of interest

None.

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