Research Article

The Effectiveness of Plyometric Training and Aquatic Training on Patellar Tendinopathy among University Level Volleyball Players

Divyashree Magendran, Buvanesh Annadurai*, Vinodhkumar Ramalingam, Kajamohideen Abdul Rahman

Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamilnadu, India

***Corresponding author:** Buvanesh Annadurai, Assistant Professor
Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamilnadu, India
Email: buvanesh.scpt@gmail.com

ORCID ID:
Divyashree Magendran: 0009-0008-6091-7933
Buvanesh Annadurai: 0000-0002-9851-2973
Vinodhkumar Ramalingam: 0000-0002-5269-0520
Kajamohideen Abdul Rahman: 0009-0002-0314-677X

Article info:
Received: 8 Mar 2025
Accepted: 31 May 2025

Citation: Magendran D, Annadurai B, Ramalingam V, Rahman KA. The Effectiveness of Plyometric Training and Aquatic Training on Patellar Tendinopathy among University Level Volleyball Players. Journal of Modern Rehabilitation. 2025;19(4):?-?

Running title: Plyometric vs Aquatic Training for Patellar Pain

Abstract

Background: Patellar tendinopathy is a prevalent overuse injury among volleyball players due to the repetitive jumping, landing, and sudden directional changes. Plyometric training enhances tendon strength and neuromuscular coordination but involves high-impact movements that may worsen symptoms. Aquatic training provides a low-impact alternative, using water's buoyancy to reduce stress while improving strength and flexibility. This study aiming to evaluate their effectiveness in reducing pain and improving function in volleyball players with patellar tendinopathy.

Method: The study recruited volleyball players aged 18-24years with diagnosed patellar tendinopathy. A total of 30 university level volley ball players who were randomly assigned into two groups: Group A Plyometric training (n=15) and Group B Aquatic training (n =15). All the players underwent pre- test measurement with Numeric Pain Rating Scale (NPRS) The Victorian Institute of Sport Assessment (VISA) Patella (P) score and the post-test were measured at the end of sixth week.

Results: Comparing pre-test and post-test values of NPRS and VISA-P between groups revealed significant differences. Group B showed better outcomes, with a mean NPRS value of 1.73 ± 0.703 compared to Group A's 3.13 ± 0.743 ($p \leq 0.05$, effect size $d = 1.93$). Similarly, Group B's

mean VISA-P score (65.80 ± 5.37) was higher than Group A's (58.73 ± 5.29) ($p \leq 0.05$, effect size d = 1.32). These results indicate that aquatic training treatment is more effective than plyometric training.
Conclusion: This study demonstrates that aquatic training is more effective than plyometric training in managing patellar tendinopathy in university volleyball players, showing significant improvements in symptoms.
Keywords: Aquatic therapy, patellar ligament, plyometric exercise, tendinopathy, volleyball.

Introduction

Patellar tendinopathy, commonly referred to as Jumper's Knee, is a debilitating overuse injury that can cause significant pain for athletes, particularly those participating in high-intensity sports such as basketball and volleyball. This condition arises from the pain and dysfunction of the patellar tendon. Failure to properly manage it will substantially impact an athlete’s performance and may even result in dire consequences in the future [1]. Patellar tendinopathy has many causes ranging from intrinsic and extrinsic issues such as chronic mechanical stress, insufficient biomechanics, and failing to give the body adequate rest breaks [2]. In the past, a wide range of treatment techniques with differing degrees of effectiveness have been used to treat patellar tendinopathy. They include conservative options like physiotherapy, load management, eccentric training, as well as advanced procedures like shockwave therapy and platelet-rich plasma injections [3]. Of these methods, two exercise techniques – plyometric training [4] and aquatic training [5] – have stood out as useful in dealing with patellar tendinopathy in university-level volleyball player. These workout styles aim to enhance neuromuscular efficiency, tendon stiffness, and overall organ performance without aggravating symptoms [6].

The study found that patellar tendinopathy (PT) was most prevalent among professional volleyball players, with a rate of 45%. Among elite athletes across nine different sports, the overall prevalence was 14.2% [7]. PT was found in 18.6% of individuals in a study including volleyball players, with 6.3% being diagnosed with bilateral PT and 12.3% with unilateral PT [8]. A study of 891 non-elite male and female athletes from seven major sports also showed that the prevalence of PT was 8.5% overall, with volleyball players having the greatest incidence at 14.4% [9].The mechanical characteristics of the patellar tendon in elite volleyball athletes were assessed. It was noted that athletes with tendinopathy had increased risk of tendon injuries due to decreased stiffness and increased tendon load intolerance.[10]

Plyometric training is commonly known to improve explosive strength, agility, and neuromuscular coordination. Plyometric training has been shown to improve adolescent volleyball players quadriceps strength, jump height, and patellar tendon morphology, particularly in tendon structural and functional adaptation. However, its use in the treatment of patellar tendinopathy remains controversial [11]. The impact of plyometric and resistance training on tendon stiffness and reported that increased tensile loading through exercises can enhance tendon strength and reduce injury risk. For effective plyometric intervention, care must be taken, however, as overloading without sufficient rest can worsen symptoms. The need to modify activity patterns of painful limbs when planning plyometric exercises for individual athletes, so that optimum training loads are maintained without excessive strain on the injured tendon [6,12].

Alternatively, the use of water as a form of therapy has increased as a method of rehabilitation for several musculoskeletal injuries such as patellar tendinopathy. The increased use of water for rehabilitation has been noted to have positive impacts on buoyancy and muscle support. This, in turn, reduces the gravitational impact on joints and tendons, allowing athletes to perform strength and endurance exercises with minimal discomfort. This makes swimming and other aquatic training forms particularly useful for patients recovering from chronic tendon difficulties. The effects of water therapy on specific health fitness index elements among volleyball players. In agreement with this Wilcox and his colleagues formulated a complex system of swimming exercises for rehabilitation of patellar tendinopathy and noticed improvement in tendon health, functional performance, as well as pain relief [5,13]. Along with these benefits, therapy increases proprioception and neuromuscular control for better overall movement and muscle control after injury. There should be active multi-modal management strategies, including water exercises, focused on basketball players suffering from patellar tendinopathy [13]. The combination of swimming and traditional strength training has produced favourable outcomes in patients with plyometric and aquatic training both have special advantages for treating patellar tendinopathy, but how well they work will depend on how severe the condition is and how each athlete reacts to treatment. The rehabilitation protocols for young volleyball players with patellar tendinopathy and found that incorporating both training modalities yielded superior results compared to traditional rehabilitation approaches [14].

By combining elements of both plyometric and aquatic training, a more comprehensive and effective rehabilitation approach can be established, ensuring optimal outcomes for athletes suffering from patellar tendinopathy [15].

Although there is evidence to support these therapies, nothing is known about how well they work in treating patellar tendinopathy, particularly in university volleyball players. The majority of earlier research has either just examined one approach or has not included a population unique to a sport. Therefore the purpose of this study is to assess how plyometric and aquatic training affect patellar tendinopathy in university volleyball players. The primary objective is to evaluate the effect of plyometric training versus aquatic training on pain and function in volleyball players with patellar tendinopathy. The study hypothesized as significant or no significant difference between the effects of plyometric training and aquatic training on pain and function in university-level volleyball players with patellar tendinopathy.

Materials and methods

Study design:

This experimental study aimed to investigate and compare the effects of plyometric training and aquatic training on pain and functional ability in volleyball players

Selection criteria:

Thirty university volleyball players (18-24 years) from DREAM STAR Sports Academy in Tiruvallur, Chennai, India participated in this study. Inclusion criteria included a clinical diagnosis of patellar tendinopathy, active volleyball training, and commitment to a six-week intervention. Exclusion criteria comprised acute injuries, systemic diseases, recent knee surgeries, and inability to adhere to the training regimen. Participants were randomly assigned to either Group A (plyometric training, n = 15) or Group B (aquatic training, n = 15).

Procedure, materials and tools:

Both groups followed a 6-week structured training protocol, with 60-minute sessions, four times a week. Each session began with a general warm-up (light cardio and dynamic stretching) and concluded with a 5-10 minutes cool-down (low-intensity exercises and static stretching). Group A (plyometric training) performed land-based exercises, including lateral bounds, single-leg hops, box jumps, depth jumps, squat jumps, and jumping lunges. These exercises consisted of three sets of 6-10 repetitions, with 60-90 seconds of rest between sets and 2-3 minutes between exercises. Group B (aquatic training) performed water-based exercises in a swimming pool, such as water jogging, cycling, leg swings, aquatic squats, leg lifts, and resisted knee flexion-extension. These exercises comprised three sets of 10-20 repetitions, with 30-60 seconds of rest between sets. The volume and intensity of the exercises in both groups were gradually increased each week based on participant performance and tolerance. The materials used in this study included jump boxes, mini hurdles, medicine balls, cones, a swimming pool, and resistance bands.

Data collection and ethical rules:

Pain levels were assessed using the Numeric Pain Rating Scale (NPRS), and functional capacity was evaluated using the Victorian Institute of Sport Assessment-Patella (VISA-P) questionnaire. Data were collected at baseline and after the six-week intervention. Written informed consent was obtained from all participants, and the study received approval from the Institutional Ethics Committee 009/12/2024/ISRB/PGSR/SCPT.

Statistical analysis:

The participants' data were analyzed using SPSS (Statistical Package for the Social Sciences) software to ensure accuracy and reliability in the results. To ensure homogeneity between groups at baseline, independent t-tests were conducted before the interventions. Additionally, independent t-tests were used to compare the differences between the plyometric training and aquatic training groups on outcome measures, including pain levels and functional capacity. paired t-tests were used to assess the within-group effects from pre-intervention to post-intervention. A significance level of $p < 0.05$ was set for all analyses.

Results

Descriptive and inferential statistical methods were employed to assess the effectiveness of plyometric training and aquatic training on patellar tendinopathy in university-level volleyball players. Independent t-tests were conducted to verify the homogeneity of the two groups at baseline, comparing age, height, weight, and body mass index (BMI). The results revealed no statistically significant differences between Group A (plyometric training) and Group B (aquatic training) in any demographic variable ($p > 0.05$), indicating that the groups were comparable prior to the intervention (Table 1). Mean and standard deviations were calculated for the NPRS (Numeric Pain Rating Scale) and VISA-P (Victorian Institute of Sport Assessment – Patella), for both groups pre- and post-intervention.

The paired t-tests for both groups (A and B) show significant reductions in NPRS and VISA-P scores ($p < 0.001$), confirming that the intervention had a statistically significant effect.

Table 1. Demographic characteristics of participants in groups

Variable	**Group A (n = 15)**	**Group B (n = 15)**	**t – value**	***p* - value**
Age (years)	21.07 ± 1.67	20.80 ± 1.42	0.45	0.65
Height (cm)	172.93 ± 5.28	171.20 ± 6.05	0.84	0.41
Weight (kg)	67.53 ± 6.11	66.27 ± 5.89	0.56	0.58
BMI (kg \ m^2)	22. 58 ± 1.94	22.57 ± 1.87	0.01	0.99

(P > 0.05 - Not Significant, no difference between the groups in baseline)

Table 2 presents the mean, standard deviation (SD), t-test, degree of freedom (df), and p-value for Group A and Group B in both pre-test and post-test. The results indicates no significant difference between Group A and Group B in pre-test values ($p > 0.05$). However, the post-test values ($p \leq 0.001$) showed a statistically significant differences between Group A and Group B. The Cohen's d value of 1.93 indicates a large effect size, exceeding the threshold of 0.8. The participants in the aquatic therapy (1.73 ± .703) was found to have better relief from pain compared with plyometric training (3.13 ± .743).

Table 2. Comparison of visa score between group (A&B)

Test	**Group – A**		**Group - B**		**t - test**	**df**	***p* - value**
	Mean	**S.D**	**Mean**	**S.D**			
Pre test	6.20	.676	6.13	.838	.241	28	.812*
POST TEST	3.13	.743	1.73	.703	5.29	28	.000**

(*- $P > 0.05$ - Not Significant) & (- $P \leq 0.05$ - Significant).**

Table 3 presents the mean, standard deviation (SD), t-test, degree of freedom (df), and p-value for Group A and Group B in both pre-test and post-test. The results indicate no significant difference between Group A and Group B in pre-test values ($p > 0.05$). A statistically significant difference between Group A and Group B in post-test values ($p \leq 0.05$). Inline with the reduction in the pain, the players VISA-P scores in the aquatic therapywere slight better compared with plyometric training. The Cohen's d value (d=1.32) indicates a large effect size, exceeding the threshold of 0.8. The participants in the aquatic therapy (65.80 ± 5.37) was found to have better improvement in functional ability comparing participants in the plyometric training (58.73 ± 5.29).

Table – 3: Comparison of visa score between group (A&B)

Test	**Group - A**		**Group – B**		t - test	df	***p* - value**
	Mean	S.D	Mean	S.D			
Pre test	48.13	3.88	47.53	4.83	.374	28	.711*
Post test	58.73	5.29	65.80	5.37	-3.62	28	.001**

(*- $P > 0.05$ - Not Significant) & (- $P \leq 0.05$ - Significant).**

Table 4, presents the mean, standard deviation (SD), t-value, and p-value for pre-test and post-test values within Group A and Group B. The results show statistically significant differences between pre-test and post-test values of pain scores in both Group A and Group B ($p \leq 0.05$), indicates players were responded well to the interventions. Similarly, the players response for VISA-P found to have a statistically significant differences between pre-test and post-test values in both Group A and Group B ($p \leq 0.05$) as shown in Table 5.

Table- 4: Comparison of nprs score within group (A&B)

Groups	Pre test		Post test		t - test	***p* - value**
	Mean	S.D	Mean	S.D		
Group- A	6.20	.676	3.13	.743	20.08	.000**
Group- B	6.13	.838	1.73	.703	33.60	.000**

(- P ≤ 0.05 - Significant).**

Table - 5: Comparison of visa score within group (A&B)

Groups	Pre test		Post test		t - TEST	***p* - value**
	Mean	S.D	Mean	S.D		
Group- A	48.13	3.88	58.73	5.29	-17.00	.000**
Group- B	47.53	4.83	65.80	5.37	-29.06	.000**

(- P ≤ 0.05 - Significant).**

The analysis within groups from pre- to post-test for both pain and functional ability was analyzed through paired t-tests. In Group A (plyometric training), participants showed significant improvements with NPRS scores going from 6.20 ± 0.68 to 3.13 ± 0.74 ($p < 0.001$), with a large effect size ($d = 4.58$), and VISA-P scores improving from 48.13 ± 3.88 to 58.73 ± 5.29 ($p < 0.001$), also with a large effect size ($d = 2.26$), indicating significant improvements in pain and function respectively. Group B (aquatic training) also demonstrated significantly reduced pain with NPRS scores of 6.13 ± 0.83 to 1.73 ± 0.70 ($p < 0.001$), with a very large effect size ($d = 5.97$), as well as increased improvements in function with VISA-P scores of 47.53 ± 4.83 to 65.80 ± 5.37 ($p < 0.001$), with a very large effect size ($d = 3.66$). Consequently, the null hypothesis is disproved.
To evaluate differences in post-test scores between groups, independent t-tests were used. According to the findings, Group B outperformed Group A in terms of results. With a t-value of 5.29 and $p = 0.0001$, Group B's post-test NPRS score (1.73 ± 0.70) was substantially lower than Group A's (3.13 ± 0.74), with a large between-group effect size ($d = 1.93$). When comparing the mean values of groups A and B on the VISA score, both groups' post-test mean values significantly increased. However, Group B, which included aquatic training, had a higher mean value of 65.80 ± 5.37, more effective than Group A (58.73 ± 5.29) with $p \leq 0.05$ and a large between-group effect size ($d = 1.32$). Therefore, the null hypothesis is disproved. There is a significant difference in the mean values at $p \leq 0.05$ between the pre- and post-tests for Groups A and B on the Numerical Pain Rating Scale (NPRS) score and VISA score.

Discussion

Jumper's knee, often referred to as patellar tendinopathy, is a common and difficult condition among athletes, especially those who play sports like basketball and volleyball that require a lot of leaping [2,7,8]. To reduce symptoms and improve tendon regeneration, a variety of therapeutic modalities have been investigated; plyometric training and aquatic training have emerged as promising options [5,6,11,].

The effects of plyometric exercise, which involves explosive movements like jumping and bounding, on muscle adaptation and tendon stiffness have been thoroughly investigated. According to Brar et al. (2021), lower limb plyometric and resistance training seems to significantly affect the stiffness of the Achilles and patellar tendons in recreational athletes [6]. Additionally, plyometric training improves jump height, strengthens the quadriceps, and alters the sonographic features of the quadriceps muscle and patellar tendon, according to a study by Harput et al. (2022) on teenage female volleyball players, suggesting that it may have a role in injury prevention and rehabilitation [11].

Conversely, aquatic training has drawn interest due to its capacity to offer resistance while lowering joint stress. According to Kamalakkannan et al. (2010), volleyball players' physical fitness metrics were considerably enhanced by aquatic training [5]. For athletes with patellar tendinopathy, swimming is a useful rehabilitation method because of the painless movement made possible by the decreased gravitational strain.

Results from combining these two training techniques have been encouraging. According to Vander Doelen and Scott's (2020) study on basketball players, a multimodal management strategy implies that combining various training methods can improve tendon rehabilitation result [13]. The significance of pain-guided activity adjustment during treatment is also emphasized by Sprague et al. (2021), who stress that planned training adaptations can enhance tendon health and function [12].

The purpose of the study was to compare the effects of aquatic and plyometric training on volley ball players with patellar tendinopathy.

In the current study, thirty volleyball players with patellar tendinopathy participated in a variety of muscle-strengthening exercises. Pre- and post-test results are used in experimental investigations. Pre and post values were documented, and on the fifth day of each week, a proper follow-up was conducted.

This study shows more improvement in aquatic group than plyometric group. On comparing VISA score and NPRS score the exercise given in aquatic training showed improvement greater than plyometric training group.

Study limitations

Although this study showed that university-level volleyball players with patellar tendinopathy responded better to aquatic training than to plyometric exercise in terms of pain reduction and functional results, it is important to recognize a number of limitations. First off, only one sports academy was included in the sample, which may have limited how broadly the results may be applied. Second, there were no follow-up evaluations to determine whether the gains were sustainable over time, and the intervention period was brief (six weeks). Furthermore, because the study only looked at volleyball players at the collegiate level, its findings might not apply to competitors in other sports or age groups

Future studies should examine the long-term impacts of aquatic and plyometric therapies, especially with regard to preserving tendon health and averting symptom recurrence. Research could also look at how well neuromuscular training works and how it can be combined with plyometric or aquatic programs. Furthermore, the findings would be more applicable if similar therapies were tested on a variety of populations, including female athletes, recreational athletes, and people with chronic tendinopathy. Besides, the outcome was more subjective than objective, which may affects study by response bias. In addition, understanding the structural alterations linked to various rehabilitation regimens may also be aided by the inclusion of objective biomechanical or imaging-based evaluations.

Conclusion

This study concludes that the Aquatic training is more effective than plyometric training on volley ball players with patellar tendinopathy. This study has improved patellar tendinopathy using aquatic training exercises. There was a significant difference in post –test values of Numerical pain rating scales, VISA-P score in group A and group B. On comparing all the two groups group B shows a marked improvement in functional activity also reducing pain in subjects with Patellar tendinopathy. These results have significant therapeutic ramifications. In order to reduce joint stress and encourage functional recovery, rehabilitation specialists may choose to include aquatic activities in tendon rehabilitation regimens. Aquatic training is a safer and more bearable option for athletes, particularly those participating in high-impact sports, to manage patellar tendinopathy without sacrificing training regularity. The use of multimodal programs in the future, such as aquatic and neuromuscular workouts, may improve results and reduce the risk of reinjury.

Ethical Considerations

Compliance with ethical guidelines (009/12/2024/ISRB/PGSR/SCPT.)

Acknowledgments

We thank the participants for their invaluable support during the study recruitment. Their contributions were instrumental in helping us reach these findings.

Authors contributions:

Design of the study, Literature search and analyses, Manuscript writing- D.M., B.A Interpretation of data, Critical revision of manuscript-V.R.,K.M.A Final approval of the version- V.R.,B.A Agreement to be accountable for all aspect of the work- B.A

Conflict of interest:

No conflict of interest

Funding:

None

References

1. Schwartz A, Watson JN, Hutchinson MR. Patellar tendinopathy. Sports health. 2015 Sep;7(5):415-20.
2. Zwerver J. Patellar tendinopathy ('jumper's knee'); a common and difficult-to-treat sports injury. Ned Tijdschr Geneeskd. 2008 Aug 16;152(33):1831-7.
3. Figueroa D, Figueroa F, Calvo R. Patellar tendinopathy: diagnosis and treatment. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2016 Dec 1;24(12):e184-92.
4. Anversha AT, Ramalingam V, Kumari JP, Sugumaran SV. Impact of plyometric training on agility, sprint and vertical jump functional performance in junior level basketball players. Journal of Physical Education and Sport. 2024 Mar 1;24(3):638-48
5. Kamalakkannan K, Vijayaragunathan N, Kalidasan R. Influence of aquatic training on selected physical fitness variables among volleyball players. Indian journal of science and technology. 2010 Jul;3(7):743-5
6. Brar KK, Bhardwaj P, Prabu RG. The influence of lower limb plyometric and resistance training on the stiffness of Achilles and patellar tendons in recreational athletes. Biomedical Human Kinetics. 2021;13(1):56-62.
7. Lian ØB, Engebretsen L, Bahr R. Prevalence of jumper's knee among elite athletes from different sports: a cross-sectional study. The American journal of sports medicine. 2005 Apr;33(4):561-7.

8. van der Worp H, van Ark M, Zwerver J, van den Akker-Scheek I. Risk factors for patellar tendinopathy in basketball and volleyball players. British Journal of Sports Medicine. 2011 Apr;45(4):380.
9. Theodorou A, Komnos G, Hantes M. Patellar tendinopathy: an overview of prevalence, risk factors, screening, diagnosis, treatment and prevention. Archives of orthopaedic and trauma surgery. 2023 Nov;143(11):6695-705.
10. Helland C, Bojsen-Møller J, Raastad T, Seynnes OR, Moltubakk MM, Jakobsen V, Visnes H, Bahr R. Mechanical properties of the patellar tendon in elite volleyball players with and without patellar tendinopathy. British journal of sports medicine. 2013 Sep 1;47(13):862-8.
11. Harput G, Toprak U, Colakoglu FF, Temel E, Saylisoy S, Baltaci G. Effects of Plyometric Training on Sonographic Characteristics of Quadriceps Muscle and Patellar Tendon, Quadriceps Strength, and Jump Height in Adolescent Female Volleyball Players. International Journal of Athletic Therapy and Training. 2022 Jun 23;28(2):89-96.
12. Sprague AL, Couppé C, Pohlig RT, Snyder-Mackler L, Silbernagel KG. Pain-guided activity modification during treatment for patellar tendinopathy: a feasibility and pilot randomized clinical trial. Pilot and feasibility studies. 2021 Dec;7:1-7.
13. Vander Doelen T, Scott A. Multimodal management of patellar tendinopathy in basketball players: a retrospective chart review pilot study. Journal of Bodywork and Movement Therapies. 2020 Jul 1;24(3):267-72
14. Biernat R, Trzaskoma Z, Trzaskoma L, Czaprowski D. Rehabilitation protocol for patellar tendinopathy applied among 16-to 19-year old volleyball players. The Journal of Strength & Conditioning Research. 2014 Jan 1;28(1):43-52.
15. Park BH, Seo JH, Ko MH, Park SH. Reliability and validity of the Korean version VISA-P questionnaire for patellar tendinopathy in adolescent elite volleyball athletes. Annals of rehabilitation medicine. 2013 Oct 29;37(5):698.
16. Hernandez-Sanchez S, Hidalgo MD, Gomez A. Responsiveness of the VISA-P scale for patellar tendinopathy in athletes. British journal of sports medicine. 2014 Mar 1;48(6):453-7.