(ISSN: 0973-7049(P))

The Bioscan AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES 21(2): S.I (2), 21942-21954, 2026 www.thebioscan.com

ADDITIVE EFFECT OF DRY NEEDLING COMBINED WITH STRENGTH TRAINING ON PAIN AND FUNCTION IN ATHLETES WITH PATELLAR TENDINOPATHY (JUMPER'S KNEE): A COMPARATIVE OBSERVATIONAL STUDY

[1]Ashi Shah, [2]Dr. Prashant Ramawat PT, [3]Dr. Sourabh Soni, [4]Dr. Jafar Khan PT, [5]Dr. Deepak Lohar PT, [6]Dr. Farukh Mohammad Pinjara, [7]Dr. Hirendra Kataria, [8]Dr. Abid R Qureshi PT, [9]Dr. Suhani Bhatnagar, Dr. Vardhman Jain

[*1]M.P.Th. scholar, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
[2] Assistant Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
[3] Assistant Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
[4]Dean & HOD, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
[5]Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
[6]Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
[7]Assistant Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
[8]Assistant Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
[9]Assistant Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
[10] Senior Consultant Physiotherapist at Synergy Health Point (Founder and Director), Mumbai, Maharashtra
Corresponding author: Ashi Shah

DOI:https://doi.org/10.63001/tbs.2026.v21.i02.S.I(2).pp21942-21954

KEYWORDS

Dry needling, patellar tendinopathy, jumper's knee, VISA-P, strength training, return to sport, athletes.

Article Info
Received: 31.05.2026
Accepted: 19.06.2026
Published: 30.06.2026

Abstract

Background: Patellar tendinopathy in athletes is defined is not just painful, but also has a measurable loss of tendon loading capacity and sport specific function. While strength training is the accepted foundation for restoring this function, the additional functional benefit of dry needling as an adjunct to a strength training programme, rather than just pain relief, has not been well defined with a currently validated and sport-specific functional outcome measure.
Objective: To evaluate the effect of dry needling combined with a strength training programme versus strength training programme alone on functional status in athletes with patellar tendinopathy using the Victorian Institute of Sport Assessment–Patellar (VISA-P) questionnaire.
Methods: 60 athletes (18–35 years) with clinically diagnosed patellar tendinopathy were divided into two groups: Group A (n=30, strength-training programme alone) and Group B (n=30, dry needling plus strength-training programme). They were treated 5 days/week for 4 weeks. VISA-P was recorded at baseline and 4 weeks.
Results: VISA-P improved significantly in both groups (Group A: 56.67±6.56 to 66.03±7.17, gain 9.37, t=22.95, $p<0.001$; Group B: 56.60±5.79 to 75.57±5.96, gain 18.97, t=39.86, $p<0.001$). At 4 weeks, Group B scored significantly higher than Group A (mean difference 9.53, t=5.60, df=58, $p<0.001$). Group B's gains were greater than the previously reported minimal clinically important difference (MCID) for VISA-P; whereas the improvement observed in Group A did not reach this clinically meaningful threshold.
Conclusions: Dry needling combined with strength training leads to a clinically meaningful functional improvement in athletes with jumper's knee, while strength training alone leads to a statistically significant but clinically incomplete functional improvement over 4 weeks.

INTRODUCTION

The knee joint's ability to tolerate the repeated high magnitude loading during jumping-type sports, which requires the coordinated function of the femur, tibia, patella, and the ligaments, tendon and surrounding musculature across the four component joints of the knee: medial and lateral tibiofemoral, patellofemoral, and proximal tibiofibular [1,2].The tendons have a specialized mechanical function, they transmit force generated by the muscles to the bones with high tensile strength and little extensibility, the stiffer and mechanically adapted patellar tendons are found in the athletes of the jumping sports and are significant for the transfer of the force generated by the muscles and to jump height and explosive performance [3]. However this same improvement, seems to be a double-edged sword. Visnes et al. have followed volleyball players over five years and found that a natural ability to jump high was also a risk factor for the development of jumper's knee, although the improvement in jumping ability with treatment was similar between athletes who developed jumper's knee and those who did not [4] — these same biomechanical characteristics that make one an excellent jumper also make one more susceptible to overload injury to the patellar tendon.

The biomechanical rationale for considering patellar tendinopathy a functional not exclusively nociceptive, issue is supported by studies of the extensor mechanism.However, a biomechanical review of the knee extensor mechanism and its relationship with patellar tendinopathy has suggested that the loading environment created by the interaction between the quadriceps force, patellofemoral joint geometry and tendon moment arm is a key factor in the development of tendinopathy and the method of rehabilitation, rather than a downstream consequence of pain alone [17].This is consistent with neuromechanical evidence that knee stiffness during movement — that is, the capacity of the knee joint to resist and control loading — is not a fixed structural property of the knee joint, but is actively regulated via reflex and voluntary neuromuscular mechanisms that can be modified by injury and pain [18].

Risk-factor reviews of sporting and occupational jumping-type loading also highlight the need to consider cumulative tendon loading, rather than any single traning variable, as the common thread between intrinsic and extrinsic risk factors described for jumper's knee [20]. Combined these three strands evidence support a working model in which the functional capacity of the patellar tendon — not just the athlete's self-reported pain — is the variable that rehabilitation should be aimed at changing, and the variable that this study is measures.

Once patellar tendinopathy develops the functional implications extend well beyond the localized pain. A systematic review of the biomechanics of jumping in patellar tendinopathy suggested that there were consistent changes in landing strategies and load distribution at the knee, which shifted the perspective of patellar tendinopathy from being a nociceptive to a biomechanical and functional problem [5].Reviews of knee joint biomechanics have also demonstrated the effect of musculoskeletal disorders on the biomechanics of common activities of daily living, including walking, running, climbing stairs, and sitting to stand, rather than just sport-specific jumping tasks, which is one reason functional outcome measures with scores for activities of daily living in addition to sport-specific assessment of pain are preferable to pain scores to track recovery [2].At the tissue level, tendons subjected to appropriate loading undergo favourable tissue structural and mechanical adaptation; however, asymmetric eccentric loading is a risk factor for the pathomechanical changes underlying tendinopathy, and these pathomechanical drivers need to be corrected not just its pain suppressed in order to achieve sustainable functional recovery [3]. This is the core concept of strength training used as the basis of rehabilitation – it is the intervention that most directly affects the loading capacity of the tendon-muscle unit itself, rather than the pain resulting from it.

The evidence base for strength training as a functional intervention for tendinopathy and jumping athletes is substantial. Kabacinski et al. identified substantial deficits in quadriceps strength in the involved knee of volleyball players with stage-1 patellar tendinopathy compared to the uninvolved knee, and suggested targeted quadriceps strengthening focusing on hamstring–quadriceps balance [6].Isokinetic knee-strength training has been found to increase the strength of the leg support compared to a basic strength training programme in high jumpers [7] and functional strength training protocols using intervals (AMRAP/EMOM) have produced significant gains in leg and abdominal strength associated with reduced ACL and jumper's-knee injury risk in athletic populations over 16 weeks [8].Weighted squat protocols have also been shown to enhance lower body explosive power in long jumpers when compared to general training [9]. The most relevant to the present outcome measure, an 8-week structured isometric/eccentric exercise programme in volleyball players with patellar tendinopathy resulted in VISA-P improvement from 55 to 89 in the intervention group with no change in controls (61 to 62), so that a well-designed strengthening programme alone can produce large functional gains over a sufficiently long period [10].

Overall, resistance training is known to enhance sports performance, promote movement efficiency and develop muscular strength in both elite and recreational athletes, and — when appropriately dosed and supervised — is safe and effective even in younger athletes, despite concerns regarding the potential for growth-related risk [11,12]. Meta-analytic evidence across elite athletes supports a large overall effect of resistant training on sport-specific performance outcomes with varying magnitude of effect dependent on the type of outcome and competitive level [13]. Application of the principles of training specificity and dynamic correspondence ensuring proper loading pattern applied during training should match the pattern of loads required in the sport has been proposed as mandatory to translate strength improvements to functional and on-court/on-track improvements [14].

Although there is considerable evidence that strength training is a functional intervention, an important clinical question remains: does adding dry needling to strengthening programme is more effective than strengthening alone in promoting a functional benefit, or is dry needling's benefit limited to pain relief without meaningfully accelerating the athletes' return to sport-ready function? This distinction is important because pain relief and functional recovery are not necessarily correlated in tendinopathy, an athlete might experience less pain but lack tendon loading capacity required for safe return to jumping sport.Functional recovery in this population is best assessed by the Victorian Institute of Sport Assessment–Patellar (VISA-P) questionnaire, self-administered, validated 8-item questionnaire evaluating pain during function along with direct measures of sporting participation, with a score of 0 (maximally symptomatic) to 100 (asymptomatic, fully active athlete) [15].VISA-P was designed to measure the athlete's functional and sporting status rather than pain intensity alone and it is the appropriate instrument to test wheather dry needling benefits extends into functional domain, whereas the existing trials of dry needling in jumper's knee have not specifically analysed or discussed the functional pathway and have not compared against the minimal clinically important difference for VISA-P.

This functional framing is also becoming evident in the broader literature on treatment: among the three treatment approaches examined for patellar tendinopathy, not only symptom scores but also functionality and jump performance were directly assessed in order for improvement in self-reported symptoms to not automatically mean the athlete had regained the ability to load the tendon in jumping sport [19].The rationale for the present study is to include VISA-P, a tool that includes sport-specific loading items instead of relying on symptom report alone, and extends it to the specific comparison of dry needling as an adjunct to structured strength training. This study asks a more clinically relevant and focused research question than "does dry needling help jumper's knee": namely, does dry needling shorten or deepen the functional recovery curve of strength training alone?

The present observational study was therefore designed to determine whether dry needling combined with a structured strength-training programme provides an advantage in terms of functional recovery (measured by VISA-P), when compared to strength training alone, over a period of 20 weeks, in athletes with patellar tendinopathy, and if this advantage is larger than the minimal clinically important difference that had been established for VISA-P. This has direct implications for return to sport decision making as a functional benefit, one that reaches the clinically important threshold, would justify prioritising dry needling as an adjunct specifically to reduce the pathway back to return to sport rather than simply to make the rehab process more comfortable.

MATERIAL AND METHODS

Study Design: Observational comparative study.

Study Setting: Department of Physiotherapy, Pacific Medical College & Hospital, Udaipur.

Study Duration: One year

Allocation: Athletes who fulfilled eligibility criteria were enrolled consecutively from the physiotherapy/orthopaedic-sports OPD and randomly divided into one of the two treatment arms using simple random sampling for group allocation. No allocation concealment, and no blinding of the participants and the treating therapist and outcome assessor, was done. No blinding or concealment was used so the study is presented as an observational comparison of two treatment protocols for routine clinical conditions rather than as a blinded randomized controlled trial.

Sample Size: Sixty athletes with clinically diagnosed patellar tendonitis (jumper's knee) between ages 18 and 35 were randomly divided into two groups: Group A (n=30) and Group B (n=30). Sample size was calculated a priori using the standard formula for comparison of two independent means, $n = 2(Z\alpha/2 + Z\beta)^2\sigma^2/d^2$, assuming a 2-tailed α of 0.05, power of 80%, and a between group effect size (Cohen's d) of around 0.8 for the VISA-P change, which is similar to effect sizes reported in previous strength training and dry needling studies using this outcome measure. This resulted in a number of minimum 26 participants per group. A total of 30 participants were enrolled per group (N = 60), which included approximately 15% margin against missing data or dropouts.

Treatment duration: 45-60 minutes per session, 5 days/ week ,for 4 weeks.

Inclusion Criteria:

- Both male and female.
- Age group between 18-35 years.
- Clinical diagnosis of Patellar tendonitis and Patient with complain of knee pain.
- Informed consent/ willingness to participate in the study

Exclusion Criteria:

- Subluxation
- Previous knee surgery
- Knee disorder other than pfp
- Recurrent patella dislocation
- Clinical signs of meniscus and ligaments lesion
- Any neurological disease

Outcome Measure: Victorian Institute of Sport Assessment–Patellar (VISA-P) questionnaire which was completed at baseline and 4 weeks. Demographic data at baseline were comparable to each other for the two study groups with respect to age, gender, BMI and type of sport (data presented in our accompanying pain-outcome study from this cohort).

PROCEDURE

Ethical clearance was obtained from the institutional ethical committee of PMCH, Pacific Medical University, Bhilo Ka Bedla, Udaipur (RAJ).

The athletes diagnosed with patellar tendonitis (jumper's knee) in the Physiotherapy Department (PHT) and Orthopedic/Sports Injury Department (OPD) were first screened for the inclusion and exclusion criteria. Prior to the treatment procedure, patients were oriented to the study and informed consent was taken. Patients were divided into two groups, with both groups being evaluated for the pre-test parameter.

60 subjects were selected as per inclusion criteria and randomly assigned to Group A and Group B.

- Group A (n=30) — received a specific exercise programme (Control group).
- Group B (n = 30) received dry needling therapy in addition to the same specific exercise programme (Observational group).

Group A (n=30) - specific exercise programme:

- Clamshell with theraband
- Knee isometrics (quadriceps, hamstring)
- Strengthening exercise for vastus medialis obliquus (VMO).
- Glutes activation (Tapping and sandbag)
- Hamstring activation (with tapping and theraband)
- Calf raises

Group B (n=30) — dry needling therapy with strength training:

- Activation of gluteus maximus with Needling
- Activation of gluteus medius with Needling
- Activation of Quadriceps with Needling.
- Release of the tibialis anterior by needle.
- Clamshell with theraband
- Knee isometrics (quadriceps, hamstring)

- Strengthening of vastus medialis obliquus
- Glutes activation (Tapping and sandbag)
- Activations of Hamstrings (with tapers and theraband)
- Calf raises

Both the groups received treatment for 45-60 minutes 4 weeks, 5 days a week for 45-60 minutes in the Department of Physiotherapy, Pacific Medical College and Hospital, Udaipur.

Statistical Analysis: Descriptive statistics (mean ± SD) were obtained for VISA-P at each time point. Pre- and post-test scores for each group were compared using paired t-tests, while post test scores were compared between group using independent-samples t-tests. Significance was considered at $p<0.05$. Improvement was also compared to the reported VISA-P minimal clinically important difference (MCID) of approximately 13 points.

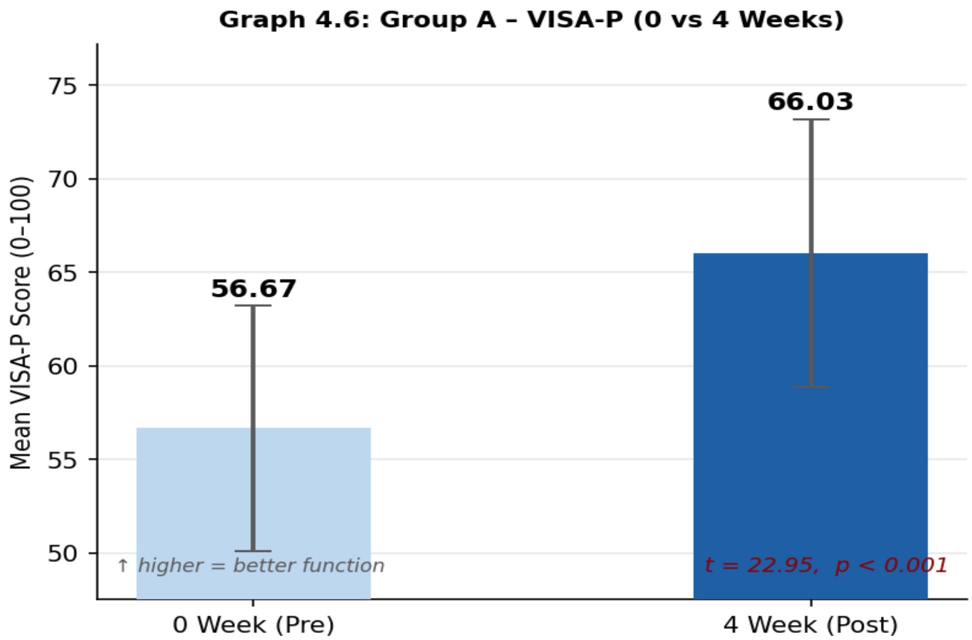
RESULTS

At baseline, both groups were well matched (mean VISA-P: Group A 56.67±6.56; Group B 56.60±5.79), and thus had similar functional status at the start of the intervention.

Table 1: Group A — VISA-P Score (0 Weeks vs 4 Weeks)

Timepoint	N	Minimum	Maximum	Mean	Std. Deviation	t-value	p-value	Result
0 Week (Pre)	30	46	67	**56.67**	6.56	**22.95**	**< 0.001**	**Significant**
4 Week (Post)	30	53	77	**66.03**	7.17			
Overall	60	46	77	**61.35**	7.97			

GRAPH 1: GROUP A – VISA-P SCORE (0 WEEK vs 4 WEEKS)

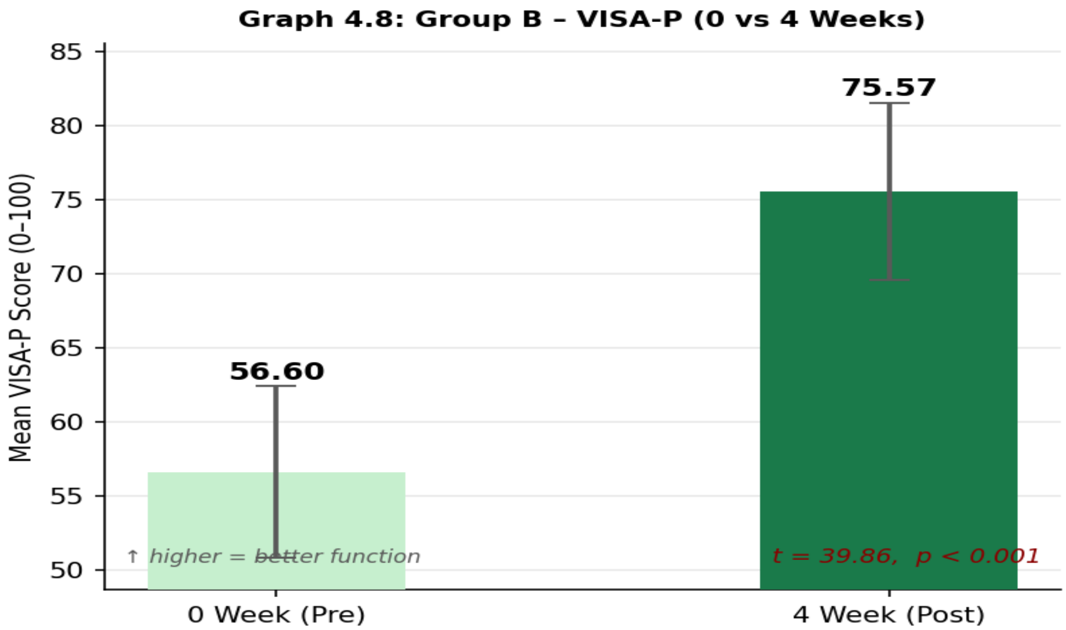


Group A's mean VISA- P gain of 9.37 points (SD 2.24) was statistically significant but fell short of the 13- point MCID, indicating incomplete functional recovery with strength training alone over 4 weeks.

Table 2: Group B — VISA-P Score (0 Weeks vs 4 Weeks)

Timepoint	N	Minimum	Maximum	Mean	Std. Deviation	t-value	p-value	Result
0 Week (Pre)	30	47	66	**56.60**	5.79	**39.86**	**< 0.001**	**Significant**
4 Week (Post)	30	59	86	**75.57**	5.96			
Overall	60	47	86	**66.08**	10.59			

GRAPH 2: GROUP B – VISA-P SCORE (0 WEEK vs 4 WEEKS)



Group B's mean gain of 18.97 points (SD 2.61) –more than double Group A's – clearly exceeded the VISA-P MCID. Individual gains ranged from 11 to 24 points; younger athletes (18-22 years) and those with normal BMI tended towards the upper ends of this range (19-24 points),while older athletes (32 -35 years) and those with overweight BMI showed smaller gains (11-16 points), consistent with slower tendon remodeling capacity in these subgroups.

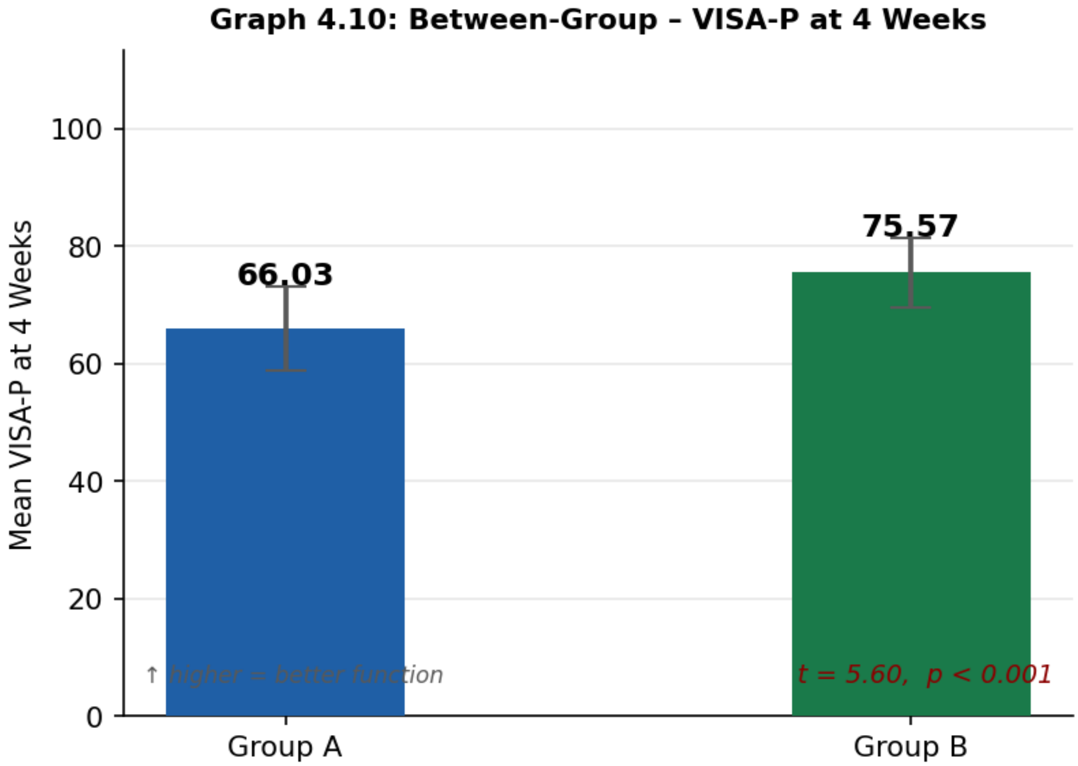
Table 3: Between-Group Comparison — VISA-P at 4 Weeks

Group	N	Mean	Std. Deviation	Std. Error Mean
Group A	30	66.03	7.17	1.31
Group B	30	75.57	5.96	1.09

Independent Samples Test

t-value	df	p-value	Mean Difference	Result
5.60	58	**< 0.001**	9.53	**Significant**

GRAPH 3: BETWEEN-GROUP COMPARISON – VISA-P AT 4 WEEKS



The between group difference was 9.53 points while slightly below the individual level MCID of 13 points, placing group B's post treatment VISA- P score in the mild impairment range in the approaching return to sports readiness, whereas group A fell in the moderate impairment range.

DISCUSSION

The functional data reported here do not follow the pattern of the "analgesic adjunct" of dry needling, where it is typically assumed that the between group functional difference was not marginal but clinically substantial with Group B almost doubled the Group A VISA-P improvement, and crossed their MCID threshold that Group A did not reach. This indicates that the use of dry needling was more than just for the relief of pain – it actually helped these patients recover from functional and sport-readiness more quickly.

This pattern is consistent with mechanistic literature on tendon loading and neuromuscular function. Knee pain has been demonstrated to inhibit voluntary and involuntary quadriceps activation through central and peripheral neural pathways [16] and so if dry needling reduces the inhibition of the quadriceps then the athletes in Group B may have made the identical strengthening exercise with more fully activated and less pain-inhibited quadriceps, thereby increasing the training stimulus provided by a training exercise.Supporting this interpretation of the "ceiling" Group A approached is an eight-week, isometric/eccentric programme in volleyball players that showed a VISA-P improvement from 55 to 89 [10]; an 8-week programme was roughly twice as long as the 4-week programme used here,suggesting

Group B's may reflect an accelerated trajectory towards a similar endpoint rather than a needling specific ceiling effect.

This is also consistent with a biomechanical, rather than just pain-report explanation. If knee stiffness during loading is under the control of dynamically regulated neuromuscular mechanisms and not fixed passive structures[18], the identical mechanical stimulus from the same strengthening programme is not necessarily required for a tendon that has been pain-inhibited compared to the tendon where that inhibition has been reduced.A review of the biomechanics of the extensor mechanism suggests that the actual loading environment around the tendon is more important than just the exercises prescribed [17]; if dry needling influenced the loading environment around the tendon enough to affect the outcome then the same exercises could reasonably be likely to produce a greater functional gain in Group B with no change in the actual dose of the exercise. This is a complementary, and not competing, mechanism to pain-inhibition, reduced pain-related inhibition and enhanced neuromuscular control of joint stiffness are physiologically linked.

The subgroup pattern - larger gains were seen in younger, normal BMI athletes and smaller gains were seen in older, overweight athletes -is consistent with known age and loading-related differences in tendon adaptability, and corresponds with the findings that the benefits of resistance training vary by athlete characteristics [11,12].This is also fits into broader risk factor literature that suggests that the tissue loading of the tendon is the common mechanism linking age, body weight, and training volume to susceptibility of the jumper's knee, which, in turn, may be a useful, low cost prognostic factor for expected recovery rate [20].

The comparative framing presented here - tested against structured exercise alone, rather than against no treatment reflects a general trend in the literature to directly compare the functional and jump-performance consequence of various treatments, rather than assuming that any significant improvement in a symptom score is functionally equivalent between treatments [19].Under that framing, the important findings is not simply that both groups improved, but that the two intervention produced functional distinguishable trajectories within the same four week window – a distinction a pain only outcomes measure would not have been positioned to detect.

From a return-to-sport perspective, Group B approached but did not reach the asymptomatic range within 4 weeks, while exceeding the individual MCID, suggesting that a combination of dry needling and strength training may be helpful to reduce, but not eliminate, supervised rehabilitation prior to sport-specific loading.It is consistent with the training specificity principles where development of strength in the gym should be progressively transposed into the athlete's sport before full function is restored [14] VISA-P improvement should be interpreted as a readiness to progress rehabilitation phase, rather than as a return to sport criteria. Applying the same standardised strengthening sequence is applied to both groups, not a individualised programme, and this leads to a similar reasoning that other standardised jumper's knee protocols[21], to strengthen the confidence in the between group difference being due to the added effect of dry needling rather than uncontrolled variation in the delivery of the exercise.

A limitation of this study is that VISA-P was only assessed up to 4 weeks, and whether the

Group B advantage diminishes, persists or increases over time has not been evaluated and would necessitate further follow-up with objective return-to-sport testing. The dosing parameters used here – session length, frequency, total duration - was also not manipulated, although it has been demonstrated that the dose has a meaningful effect on outcome in exercise knee rehabilitation without regard to exercise type [23] and the present 4-week intervention period only reflects the early and steepest portion of a potentially longer tendon – adaptation curve for both groups[22].

CONCLUSION

Dry needling with strength training resulted in a clinically significant functional improvement, which is greater than the minimal clinically important difference for VISA-P, in athletes with patellar tendinopathy compared with strength training alone, which produced a statistically significant, but clinically incomplete functional improvement during the 4-week period.

The results of this study support the use of dry needling as an adjunct to strength training, specifically to accelerate functional recovery toward return to sport readiness, and focusing on slower recovery trajectories in high BMI and older athletes.

Further studies with longer follow-up period including objective return to sport testing should be performed to determine if this functional advantage is sustained beyond the acute rehabilitation period.

Future trials should extends the outcome window against known tendon-adaptation timeframes [22] and include direct assessment of jump performance in addition to VISA-P as part of the growing trend toward outcomes being compared to a functional time frame in this field [19] to ensure that the four-week functional benefit observed here persists as the strength training is continued over a longer time horizon.

REFERENCES

1. Hirschmann MT, Müller W. Complex function of the knee joint: the current understanding of the knee. Knee Surgery, Sports Traumatology, Arthroscopy. 2015 Oct;23:2780-8.
2. Zhang L, Liu G, Han B, Wang Z, Yan Y, Ma J, Wei P. Knee joint biomechanics in physiological conditions and how pathologies can affect it: a systematic review. Applied Bionics and Biomechanics. 2020;2020(1):7451683.
3. Weisskopf L, Hesse T, Sokolowski M, Hirschmüller A. Tendons and Jumping: Anatomy and Pathomechanics of Tendon Injuries. In: Management of Track and Field Injuries. Cham: Springer International Publishing; 2021 Dec 2. p. 21-29.
4. Visnes H, Aandahl HÅ, Bahr R. Jumper's knee paradox—jumping ability is a risk factor for developing jumper's knee: a 5-year prospective study. British Journal of Sports Medicine. 2013 May 1;47(8):503-7.
5. Van der Worp H, de Poel HJ, Diercks RL, Van Den Akker-Scheek I, Zwerver J. Jumper's knee or lander's knee? A systematic review of the relation between jump biomechanics and patellar tendinopathy. International Journal of Sports Medicine. 2014 Jul;35(08):714-22.
6. Kabacinski J, Murawa M, Fryzowicz A, Gorwa J, Dworak LB. Lower extremities strength differences in female volleyball players with stage 1

patellar tendinopathy. The Journal of Strength & Conditioning Research. 2022 Aug 1;36(8):2230-5.
7. Li Z, Xu J, Ou S. Isokinetic knee muscle strength characteristics in high jump athletes. Revista Brasileira de Medicina do Esporte. 2022 Oct 24;29:e2022_0276.
8. Siantoro G, Mukhtarsyaf F, Kartiko DC, Fathir LW, Setiawan D, Widiawati P, Al Ardha MA, Kustrapsila PS, Wijaya PW. Strength development using functional training (FST) AMRAP and EMOM to minimum sports injury anterior cruciate ligament (ACL) & jumper knee for basketball students athlete. Journal of Physical Education and Sport. 2023 Dec 1;23(12):3478-86.
9. Zong P. Strength training of long jump athletes. Revista Brasileira de Medicina do Esporte. 2023;29:e2022_0278.
10. Gruodis A, Sipavičienė S. Effects of therapeutic exercise on pain, range of motion, and patellar tendon in volleyball players with jumper's knee. Reabilitacijos Mokslai: Slauga, Kineziterapija, Ergoterapija. 2025;2(33):119-28.
11. Suchomel TJ, Nimphius S, Bellon CR, Stone MH. The importance of muscular strength: training considerations. Sports Medicine. 2018 Apr;48(4):765-85.
12. Legerlotz K, Marzilger R, Bohm S, Arampatzis A. Physiological adaptations following resistance training in youth athletes—a narrative review. Pediatric Exercise Science. 2016 Nov 1;28(4):501-20.
13. Makaruk H, Starzak M, Tarkowski P, Sadowski J, Winchester J. The effects of resistance training on sport-specific performance of elite athletes: a systematic review with meta-analysis. Journal of Human Kinetics. 2024 Apr 15;91(Spec Issue):135.
14. Stone MH, Hornsby WG, Suarez DG, Duca M, Pierce KC. Training specificity for athletes: Emphasis on strength-power training: A narrative review. Journal of Functional Morphology and Kinesiology. 2022 Nov 16;7(4):102.
15. Palazón-Bru A, Rodríguez MI, Mares-García E, Hernández-Sánchez S, Carbonell-Torregrosa MÁ, Gil-Guillén VF. The Victorian Institute of Sport Assessment Scale for Patellar tendinopathy (VISA-P): a reliability generalization meta-analysis. Clinical Journal of Sport Medicine. 2021 Sep 1;31(5):455-64.
16. Seeley MK, Lee H, Son SJ, Timmerman M, Lindsay M, Hopkins JT. A review of the relationships between knee pain and movement neuromechanics. Journal of Sport Rehabilitation. 2021 Dec 22;31(6):684-93.
17. Dan M, Parr W, Broe D, Cross M, Walsh WR. Biomechanics of the knee extensor mechanism and its relationship to patella tendinopathy: a review. Journal of Orthopaedic Research®. 2018 Dec;36(12):3105-12.
18. Ludvig D, Plocharski M, Plocharski P, Perreault EJ. Mechanisms contributing to reduced knee stiffness during movement. Experimental Brain Research. 2017 Oct;235:2959-70.
19. López-Royo MP, Bataller-Cervero AV. Functionality and jump performance in patellar tendinopathy with the application of three different treatments. Journal of Science and Medicine in Sport. 2024 Oct 1;27(10):702-7.

20. Tiemessen IJ, Kuijer PP, Hulshof CT, Frings-Dresen MH. Risk factors for developing jumper's knee in sport and occupation: a review. BMC Research Notes. 2009 Dec;2:1-6.

21. Kaux JF, Forthomme B, Namurois MH, Bauvir P, Defawe N, Delvaux F, Lehance C, Crielaard JM, Croisier JL. Description of a standardized rehabilitation program based on sub-maximal eccentric following a platelet-rich plasma infiltration for jumper's knee. Muscles, Ligaments and Tendons Journal. 2014 May 8;4(1):85.
22. Bohm S, Mersmann F, Arampatzis A. Human tendon adaptation in response to mechanical loading: a systematic review and meta-analysis of exercise intervention studies on healthy adults. Sports Medicine-Open. 2015 Dec;1(1):7.
23. Young JL, Rhon DI, Cleland JA, Snodgrass SJ. The influence of exercise dosing on outcomes in patients with knee disorders: a systematic review. Journal of Orthopaedic & Sports Physical Therapy. 2018 Mar;48(3):146-61.