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EFFECT OF A STRUCTURED STRENGTH TRAINING PROGRAMME ON PAIN AND FUNCTION IN ATHLETES WITH PATELLAR TENDINOPATHY (JUMPER'S KNEE): AN OBSERVATIONAL STUDY

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KEYWORDS

Dry needling, patellar tendinopathy, jumper's knee, Visual Analogue Scale, strength training, athletes.

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Abstract

Background: Patellar tendinopathy ("jumper's knee") is an overuse injury of the knee extensor mechanism seen frequently in jumping- and sprinting-based sports, producing activity-related anterior knee pain that is disabling for competitive athletes. Exercise-based rehabilitation is well established, but the additional pain-relieving value of dry needling layered onto a strength-training programme has not been adequately isolated in observational, real-world sporting cohorts.

Background: Patellar tendinopathy ("jumper's knee") is an overuse injury of the knee extensor mechanism that is common in physical activity involving jumping or sprinting and causes activity related anterior knee pain that is disabling for competitive athletes.Exercise-based rehabilitation is a well-established technique, but the additional pain-relieving effects of dry needling on a strength training program has not been adequately isolated in observation, real world sporting cohorts.

Objective: To compare the effect of dry needling combined with a strength-training programme against strength training alone on pain among athletes with patellar tendinopathy.

Methods: The study included 60 athletes (18-35 years old) with a clinically diagnosed patellar tendinopathy who were randomly divided into two groups: Group A (n=30 strength training programme alone,) and Group B (n=30 dry needling plus the same strength training programme,).Both groups were treated 5 days per week for 4 weeks. The Visual Analogue Scale (VAS) was used to measure pain at baseline and at 4weeks.

Results : Both groups showed a significant reduction in VAS from baseline to 4 weeks (Group A: 6.50±1.11 to 5.43±1.10,t= 11.22, $p < 0.001$; Group B: 6.50±1.11 to 3.57±0.82,t= 25.12,$p< 0.001$) At 4 weeks, Group B's pain was significantly lower at 4 weeks than Group A's (mean difference 1.87, t=7.44, df=58, $p<0.001$).

Conclusion: Adding dry needling in a strength training program significantly reduces short-term pain in athletes with Jumper's knee more effectively than strength training alone.

INTRODUCTION

Patellar tendinopathy, or jumper's knee, is a painful condition of the knee extensor mechanism associated with microscopic tears in the patellar tendon [1].It occurs disproportionately in athletes engaged in sports that involve high eccentric loading of the quadriceps muscles and repetitive jumping and landing -volleyball, basketball, long-distance running, high jump, long jump, and skiing- and typically presents as localized tenderness just below the patella, and tends to become more troublesome with loading activities including stair descent and jumping [1,2].The condition is classified as an overuse injury rather than an acute traumatic one, due to repetitive, cumulative, mechanical stress on the body, and not a specific injury, and this is relevant to the way that pain is understood and treated in this population [1].

There are several intrinsic and extrinsic risk factors associated with jumper's knee which include ligamentous laxity, quadriceps or hamstring tightness, an increased Q-angle, abnormal patellar height, history of knee inflammation, training volume, ground surface hardness, body mass index, and leg-length discrepancy [3,4].Regardless of the precipitating factor, the clinical scenario that leads to presentation to a physiotherapy clinic is one complaint: pain that decreases training load, competition readiness and confidence in the affected limb. Anterior knee pain in athletes is not a local problem; knee pain has been demonstrated to affect both voluntary and involuntary inhibitory control of the quadriceps, and if sustained, these neuromuscular changes can impact the way the knee's articular cartilage responds to the loading of the knee during movement, thereby affecting long-term knee health [2]. This makes early,effective pain control in jumper’s knee not merely a comfort measure but a functional and even a joint protective priority.

To understand the cause of jumper's knee pain, it is important to differentiate the older concept of "tendinitis", which suggests a predominantly inflammatory process, from that of "tendinosis", which reflects chronic degenerative changes resulting from repetitive microtrauma and lack of a significant inflammatory response. As most cases of clinical presentation demonstrate a combination of structural and functional abnormality, and not pure inflammation, the all-encompassing term tendinopathy is now preferred, and a shift in terminology reflect a shift in thinking from treating the pain as inflammation to be suppressed to treating the sensitized load intolerant tissue and nervous system state and recalibrating through structural and neurophysiological pathways [17].

There are two mechanisms of the nervous system that play a key role in this recalibration. Peripheral sensitization occur at site of tendon injury, inflammatory mediators released after tissue damage including prostaglandin E2 released by neutrophils in the early injury phase - lower the activation threshold of local nociceptors, resulting in primary hyperalgesia that is directly related to continued tissue pathology that resolves as the tendon heals. However in central sensitization, the central nervous system is becoming more responsive: neurons in the dorsal horn become more excitable, their receptive fields expand, and pain can be felt beyond the primary site of peripheral damage, and is maintained by changes in microglial and astrocyte activity, cell excitability, and gene expression independent of ongoing peripheral damage.This is an important distinction clinically because it helps to explain why interventions which only affect the local tissue may not be as effective as they could be at resolving centrally maintained pain, and dry needling has been suggested to address this gap.

Dry needling is a minimally invasive treatment using a fine monofilament needle to inserted into symptomatic soft tissue to decrease pain and disability [9].Several mechanisms of its analgesic action have been suggested. Peripherally, needles inserted into a trigger point have been shown to decrease the sensitivity of the local nociceptor cells, and to increase the blood flow and tissue oxygenation in the surrounding area [20].At the spinal and supraspinal level, peripheral nociceptive drive reduction, decreased activity in dorsal horn neurons and modulation of pain-processing areas of the brainstem, directly targeting the central sensitization pathway outlined above [11,12] are all potential mechanisms by which trigger-point dry needling may decrease the excitability of the central nervous system .Needle depth seems to have some impact: superficial needles primarily affects skin and superficial connective tissue, have greater effects on pain, while deeper insertion into fascia and muscle is more effective [19].However, needling of shortened, hyperirritable muscle fibres may also have a mechanical effect on length–tension relationships and reduce tissue stiffness, through effects on the muscle spindle which could provide another non-purely-neural pathway to pain relief [21].

Clinical evidence for dry needling in patellar tendinopathy as opposed to myofascial pain syndromes as a whole, but this is promising. A recent RCT of ultrasound guided dry needling (UST) in patients with jumper's knee showed a significant decrease in pain and an improvement in function when UST was combined with conventional physiotherapy and an imaging trend showed reduced tendon thickness [5]. There has also been case-level evidence of meningful pain reduction from ultrasound guided dry needling in patellar tendinopathy and suprapatellar tendinitis [6,7] and a systematic review and meta-analysis of trigger-point dry needling for knee pain syndromes overall showed positive results for pain outcomes [8].Physiological studies of dry needling's mechanism of action have all come to the same conclusion that its analgesic effect stimulates both peripheral and central pain-processing pathways, which align with the multifactorial nature of pain in tendinopathy discussed above [10,22].

Meanwhile, exercise based strength training is the most widely accepted foundation for jumper's knee management and several trials and reviews have shown that eccentric, isometric, and resistance-based strengthening can reduce pain and early return to training [13,18]. Isometric exercise in particular has been shown to produce an acute analgesic effect and reduce cortical inhibition in patellar tendinopathy suggesting that loading itself modulate the pain system rather than simply strengthening the muscle-tendon unit [23]. However For patellar tendinopathy, the optimal dosing parameters to best alleviate pain rather than improving overall function are not as well defined as for other conditions, such as knee Osteoarthritis, where there is more mature evidence regarding the dosing parameters [16].

The pain-specific, additive effects of adding dry needling to a well-designed strength training programme in an actual athlete population with a validated, athlete-friendly pain questionnaire is an aspect that has not been clearly isolated in the literature. The Visual Analogue Scale (VAS) is a valid and reliable an interval-level measure of subjective pain intensity which is appropriate for the assessment of week-to-week change in a sporting rehabilitation context, and is widely used to measure pain in musculoskeletal disorders [14,15].The majority of previous dry needling trials for patellar tendinopathy do not have any specific statistical power or focus on pain trajectory alone, but rather on multiple other outcomes; and few compare dry needling with strengthening directly in athletes, rather than in general patellar tendinopathy patients. The present study builds on the gap, which refers to the lack of a focused, comparative pain-outcome analysis of the adjunct of dry needling to strength training in athletes suffering from jumper's knee.

Therefore, the aim of the present observational study was to isolate and compare the pain relieving effect, as measured by VAS, of the same strength training programme alone versus the same strength training programme dry needling in athletes with clinically diagnosed patellar tendinopathy. The clinical relevance of determining if dry needling is a meaningful adjunct to strengthening for inducing meaningful pain relief is clear: earlier onset of pain relief means the athlete can tolerate the loading phase of rehabilitation earlier ,which in turn may shorten the overall pathway back to training and competition.

MATERIAL AND METHODS

Study Design: Observational comparative study.

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

Allocation: Eligible athletes were enrolled consecutively from the physiotherapy/orthopaedic-sports OPD and randomized into the two treatment groups by simple random sampling for group allocation. There was no concealment of allocation and there was no blinding of participants, treating therapist, or outcome assessor. As no blinding or concealment was performed, no claim can be made that the study is a blinded randomized controlled trial, but rather an observational comparison of two treatment protocols under routine clinical conditions.

Sample Size: Sixty athletes aged 18-35 years with clinically diagnosed patellar tendonitis (jumper's knee) were selected and evaluated for pre-test parameters. 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 VAS 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.

Study Duration: One year.

Treatment Duration:: 45-60 minute per session, 5 days a week, for 4 weeks.

INCLUSION CRITERIA:

- Both male and female
- Age group between 18-35 years
- Clinical diagnosis of patellar tendonitis without complaint of knee pain
- Unwillingness to provide informed consent.

EXCLUSION CRITERIA:

- Patellar Subluxation
- Previous history of knee surgery
- Knee condition other than patellofemoral pathology
- Recurrent patella dislocation
- Any neurological disease.
- Clinical evidence of meniscus and ligaments lesion

Outcome Measure: Visual Analogue Scale (VAS) — a 10 cm line marked with "no pain" and "worst imaginable pain" recorded at baseline 4 weeks.

Procedure: Ethical clearance was obtained from institutional ethics committee, screening against inclusion/exclusion criteria. Eligibal athletes were briefed about the study, and informed consent were taken from athletes diagnosed with patellar tendonitis in physiotherapy/orthopaedic-sports OPD. There were 60 subjects, who were randomly allocated to two groups (Group A and Group B) as described earlier, with each athlete completing baseline VAS scoring prior to their first treatment session.

Group A (n=30):received a strength training programme only

- Theraband - resisted clamshells
- Isometric holds for quadriceps and hamstrings
- Vastus medialisobliquus- focused strengthening
- Gluteal activation using tapping cues and sandbag resistance.
- Hamstring activation using tapping cues and theraband resistance
- Calf raises

Group B (n=30): received the same level of strength training programme combined with dry needling

- Gluteus Maximus activation with dry needling;

- Gluteus Medius activation with dry needling;
- Quadriceps activation with dry needling;
- Tibialis anterior release with dry needling;

Followed by the same strength-training exercises as in Group A (clamshell with theraband; knee isometrics; vastus medialis obliquus strengthening; gluteal activation; hamstring activation; calf raises).

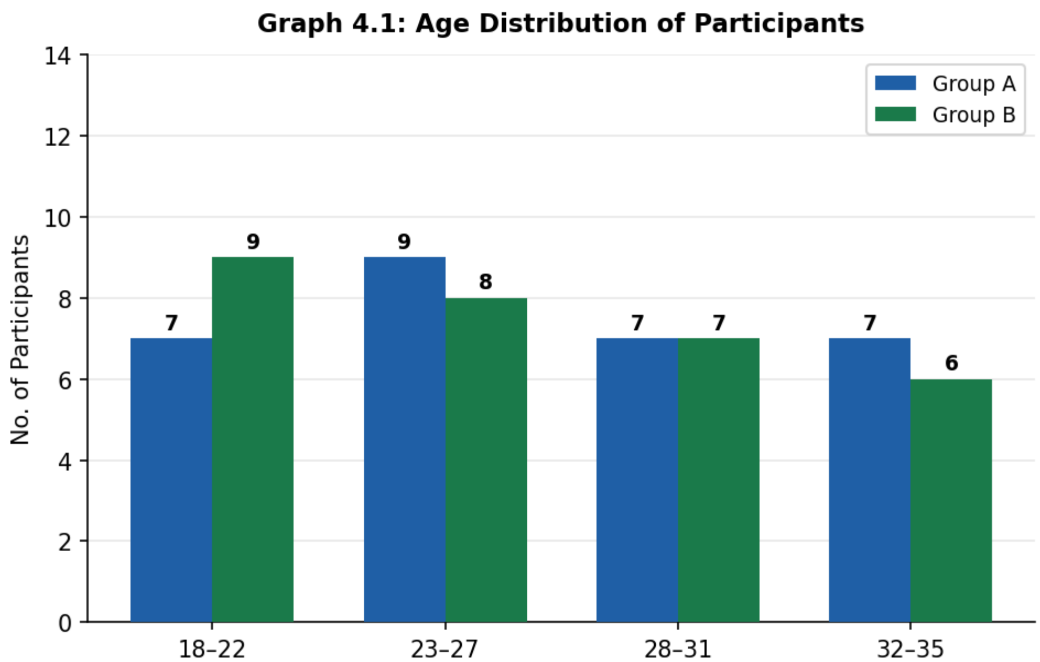
Statistical Analysis: Descriptive statistics(mean ± SD) werew calculated for VAS at each timepoint. Pre- and post-intervention scores in each group were compared using paired t-tests, and post-intervention scores between groups were compared with an independent-samples t-test. Significance was set at $p< 0.05$.

RESULTS

Table 1: Age Distribution of Participants

Age Group (Years)	Group A (n)	Group A (%)	Group B (n)	Group B (%)	Total (n)	Total (%)
18–22	7	23.3%	9	30.0%	16	26.7%
23–27	9	30.0%	8	26.7%	17	28.3%
28–31	7	23.3%	7	23.3%	14	23.3%
32–35	7	23.3%	6	20.0%	13	21.7%
Total	**30**	**50%**	**30**	**50%**	**60**	**100%**

GRAPH 1: AGE DISTRIBUTION OF PARTICIPANTS



Both groups were broadly comparable in age (mean 26.9 years, Group A; 26.3 years, Group B),consistent with the peak reported prevalence window for jumper's knee.

Table 2: Gender Distribution of Participants

Gender	Group A (n)	Group A (%)	Group B (n)	Group B (%)	Total (n)	Total (%)
Male	16	53.3%	14	46.7%	30	50.0%
Female	14	46.7%	16	53.3%	30	50.0%
Total	**30**	**50%**	**30**	**50%**	**60**	**100%**

GRAPH 2: GENDER DISTRIBUTION OF PARTICIPANTS

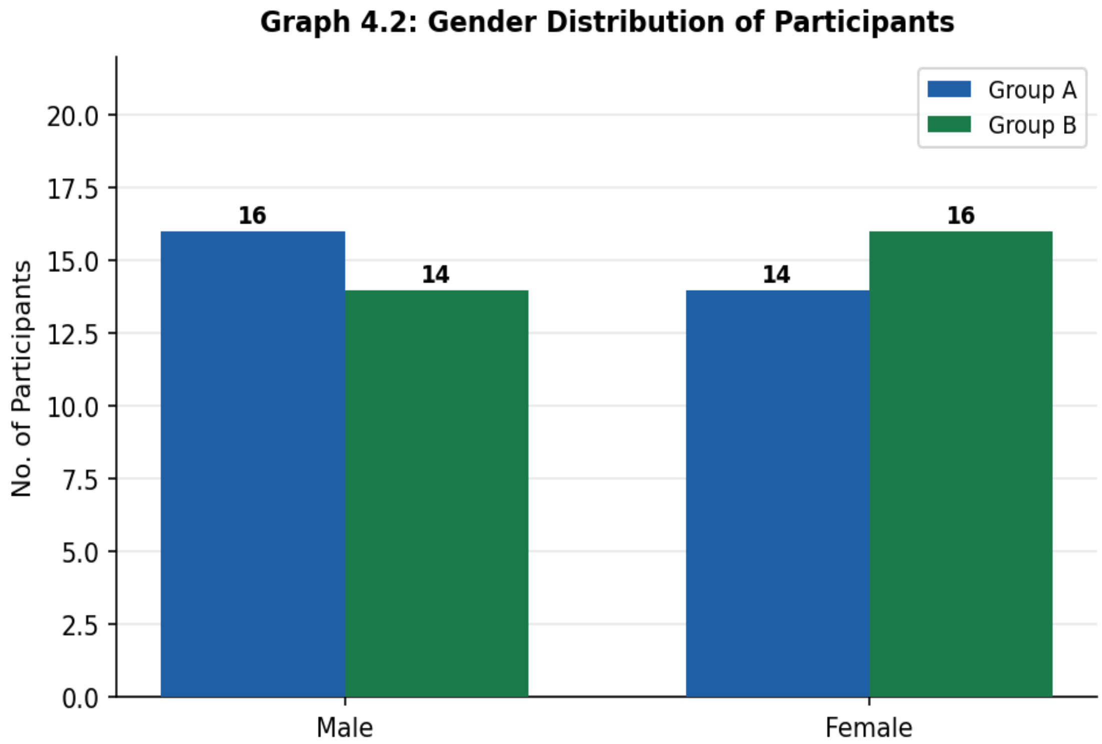


Table 3: BMI Category Distribution

BMI Category	Range (kg/m²)	Group A (n=30)	Group B (n=30)	Total (n=60)
Underweight	< 18.5	0 (0.0%)	0 (0.0%)	0 (0.0%)
Normal	18.5–24.9	21 (70.0%)	22 (73.3%)	43 (71.7%)
Overweight	25–29.9	9 (30.0%)	8 (26.7%)	17 (28.3%)
Obese	**≥ 30**	**0 (0.0%)**	**0 (0.0%)**	**0 (0.0%)**

GRAPH 3: BMI CATEGORY DISTRIBUTION

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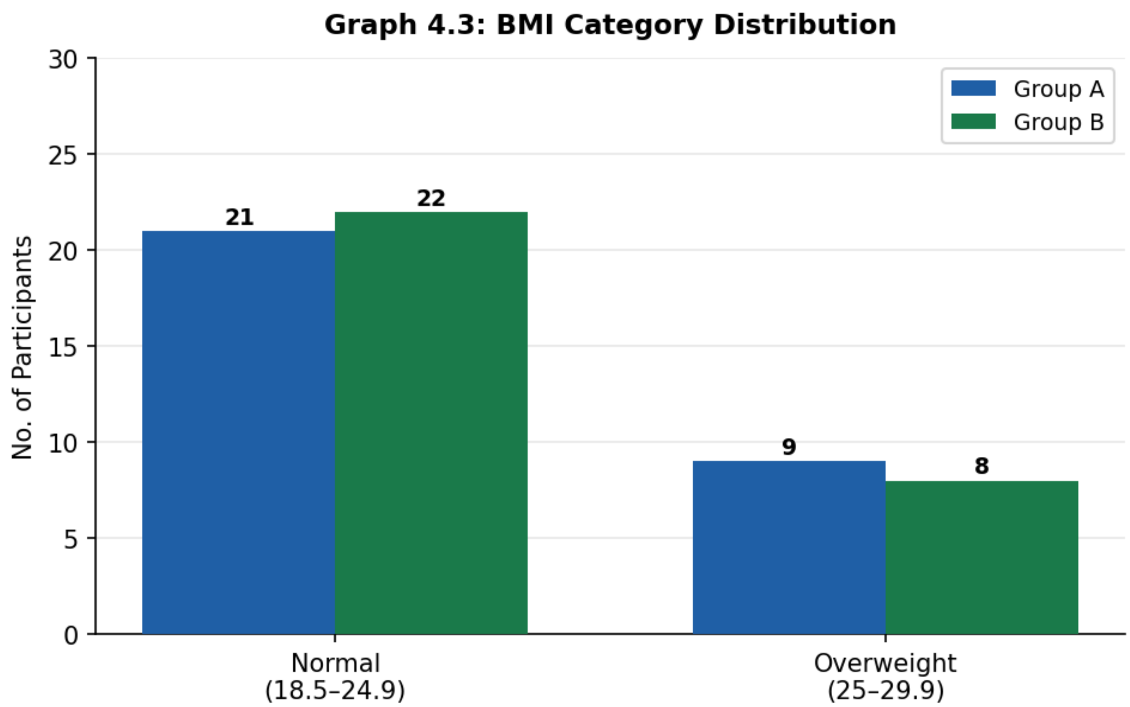
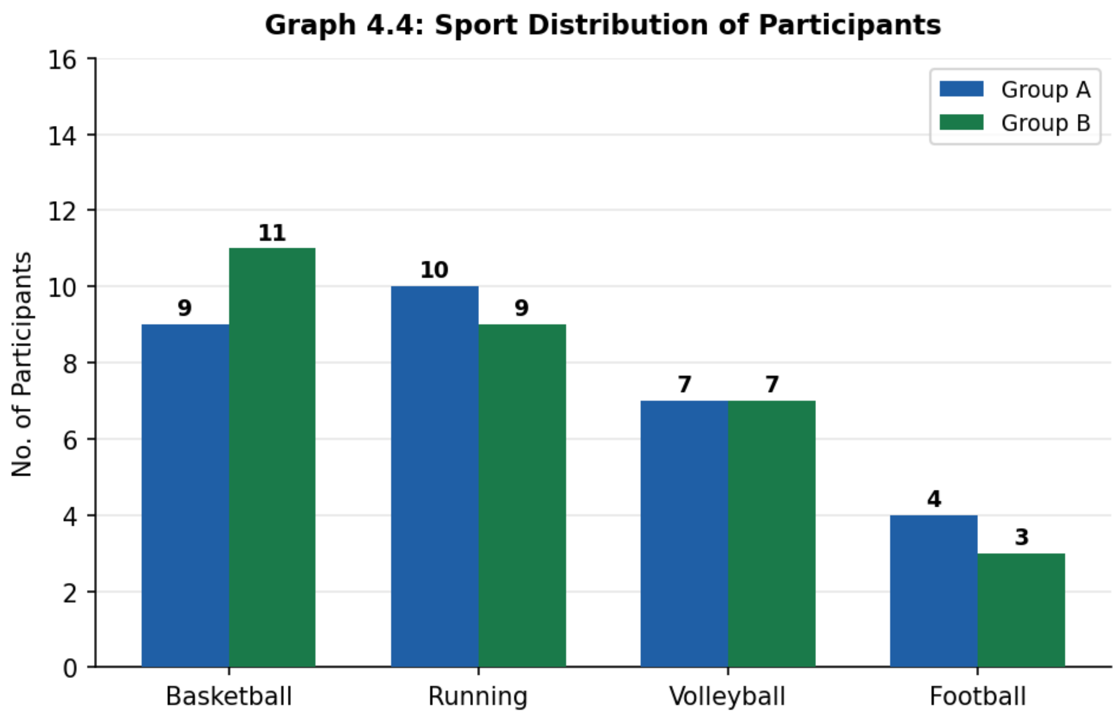


Table 4: Sport Distribution of Participants

Sport Type	Group A (n=30)	Group B (n=30)	Total (n=60)
Basketball	9 (30.0%)	11 (36.7%)	20 (33.3%)
Running	10 (33.3%)	9 (30.0%)	19 (31.7%)
Volleyball	7 (23.3%)	7 (23.3%)	14 (23.3%)
Football	4 (13.3%)	3 (10.0%)	7 (11.7%)
Total	**30 (50%)**	**30 (50%)**	**60 (100%)**

GRAPH 4.4: SPORT DISTRIBUTION OF PARTICIPANTS



Group A and B were comparable at baseline across age, gender, BMI and sport distribution, supporting the validity of the between-group comparison that follow.

Table 5: Group A — VAS Score (0 Week vs 4 Weeks)

Timepoint	N	Minimum	Maximum	Mean	Std. Deviation	t-value	p-value	Result
0 Week (Pre)	30	5	8	**6.50**	1.11	**11.22**	**< 0.001**	**Significant**
4 Week (Post)	30	4	8	**5.43**	1.10			
Overall	60	4	8	**5.97**	1.13			

GRAPH 5: GROUP A – VAS SCORE (0 WEEK vs 4 WEEKS)

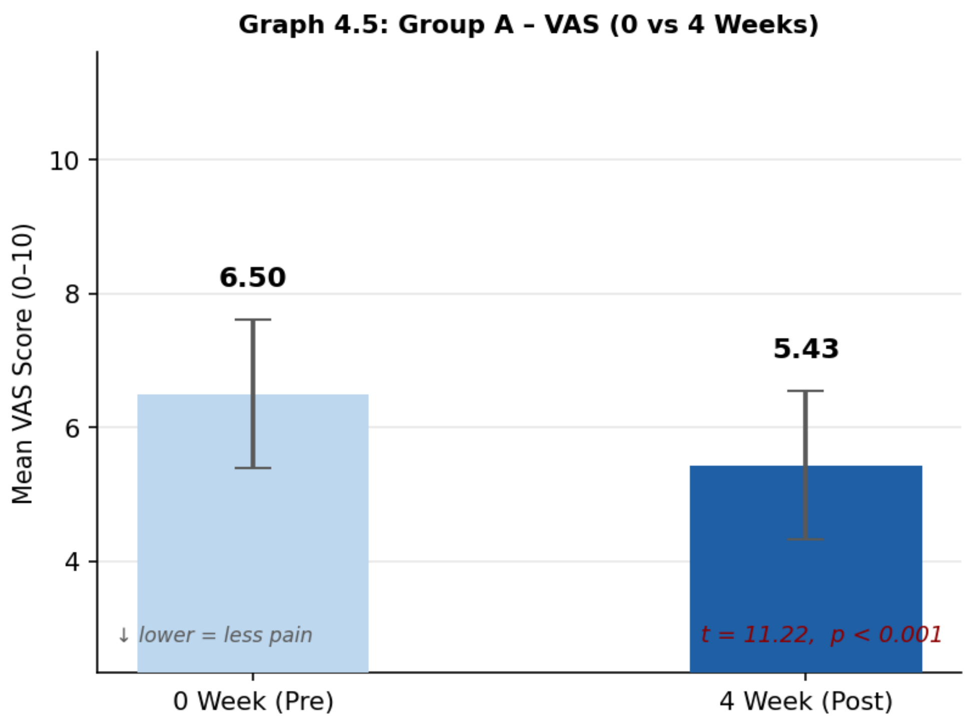
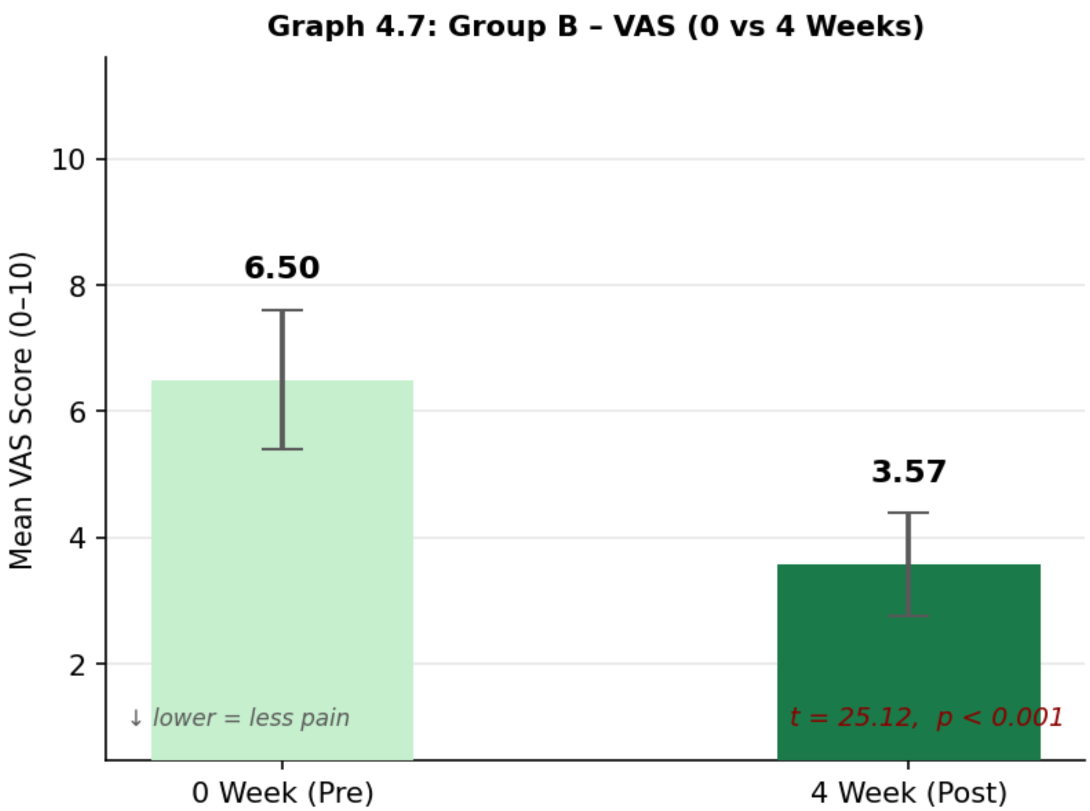


Table 6: Group B — VAS Score (0 Week vs 4 Weeks)

Timepoint	N	Minimum	Maximum	Mean	Std. Deviation	t-value	p-value	Result
0 Week (Pre)	30	5	8	**6.50**	1.11	**25.12**	**< 0.001**	**Significant**
4 Week (Post)	30	2	6	**3.57**	0.82			
Overall	60	2	8	**5.03**	1.74			

GRAPH 6: GROUP B – VAS SCORE (0 WEEK vs 4 WEEKS)



Group B's mean VAS fell by 2.93 points, nearly three times the 1.07 point reduction seen in Group A moving athletes from moderate to severe loading pain into the mild to moderate range.

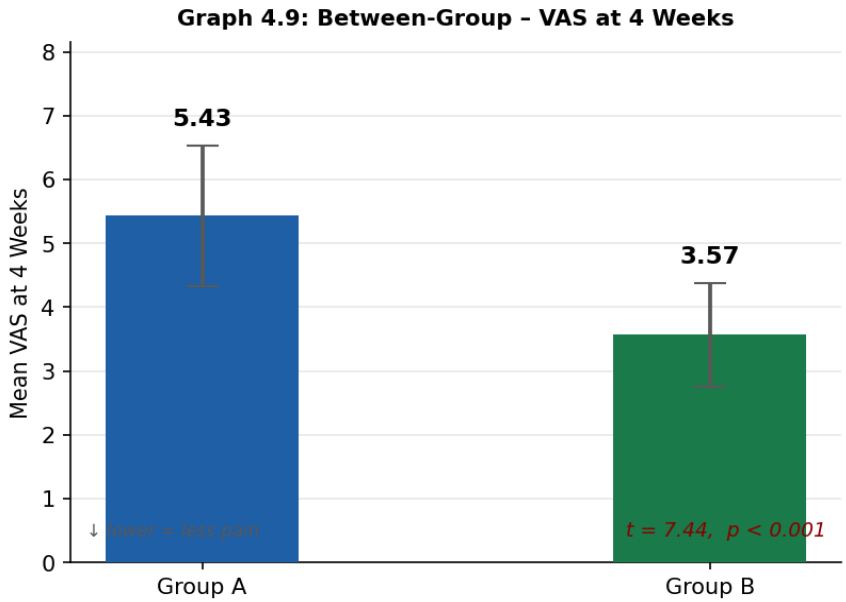
Table 7: Between-Group Comparison — VAS at 4 Weeks

Group	N	Mean	Std. Deviation	Std. Error Mean
Group A	30	5.43	1.10	0.20
Group B	30	3.57	0.82	0.15

Independent Samples Test

t-value	df	p-value	Mean Difference	Result
7.44	58	**< 0.001**	1.87	**Significant**

GRAPH 7: BETWEEN-GROUP COMPARISON – VAS AT 4 WEEKS



DISCUSSION

Both interventions were found to be statistically significant for reducing pain after four weeks, and the size of the effect in Group B was larger, and this pattern is consistent with rather than contradicted by,the existing literature on the use of dry needling in patellar tendinopathy. Sharif et al. found that ultrasound guided dry needling combined with conventional physiotherapy was more effective at reducing pain and improved function in patients with jumper's knee and that there was a tendency towards decreased tendon thickness [5]which supports a true additional analgesic effect of needling beyond the placebo effect provided by additional clinician contact time .Case level reports of ultrasound guided dry needling of the patellar and suprapatellar tendinopathy have similarly reported clinically significant pain reduction [5,6], and a systematic review of trigger point dry needling for knee pain syndromes overall reported consistent favourable effects on pain outcomes [8].

The magnitude of pain relief seen in group B is plausible and appropriate with the proposed dual pathway mechanism of dry needling. The peripheral activation of gluteal, quadriceps, and tibialis anterior sites around the knee likely reduced the sensitivity of the nociceptors (pain receptors) in the surrounding areas, and enhanced local blood flow [20] which contributed to the peripheral sensitization component of tendinopathy pain. Centrally, peripheral nociceptive drive, which would not be expected to be directly addressed by pure strengthening of the muscle-tendon unit, has been shown to be reduced by needling, which in turn reduced activity of dorsal horn neurons and modulated brainstem pain-processing regions [11,12].This may account for the fact that Group A showed an improvement which was statistically significant, but quite small; the strengthening alone may have actually increased the tolerance for the load on the tissue without down-regulating the already-sensitized nervous system.

It is also important to note that isometric loading is an acute analgesic effect in patellar tendinopathy through reduced cortical inhibition [23] which perhaps explains the genuine, even though less pronounced, effect seen in Group A. This is not a “treatment versus no treatment” comparison, but rather whether or not there is any added benefit, and the between-group difference of 1.87 VAS points ($t=7.44$, $p<0.001$) suggests there is, to the degree that it adds to what loading provides.This is similar to what is clinically observed: Dry needling combined with appropriate rehabilitation is more effective than exercise and needling alone in reducing symptoms .

A limitation worth acknowledging is that this trial did not employ a ultrasound guided needling arm or a sham needle group, so the relative importance of the precision of the needle placement and nonspecific procedural effects on the reduction of pain cannot be separated. The 4 – week observation window also evaluates only short term analgesia whether the between group advantage is maintained upon return to full training load is not addressed by this study and would require longer follow – up.

CONCLUSION

Both groups had statistically significant decreases in pain over four weeks, showing that strength training is effective as a foundation for pain management in patellar tendinopathy. This dry needling intervention did however create a significant difference between the two groups, with a difference of 1.87 VAS points (t=7.44, p<0.001) in favour of the combined intervention.

This indicates that the dry needling provides additional analgesia beyond the analgesia provided by loading alone. Given that isometric loading alone has an acute analgesic effect due to a decrease in cortical (central) inhibition [23] it is understandable that Group A experienced a significant but less marked improvement, while Group B experienced a more significant improvement, which may be due to a complementary mechanism from needling.

The clinical application of this includes the use of dry needling alongside, not in place of, of exercise-based rehabilitation, particularly when faster pain control would help an athlete tolerate loading sooner. The interpretation here is offered with caution as there are not direct head-to-head trials comparing needling to exercise alone within this population and this study design does not allow for a complete separation of the effect of needling from possible interaction effects.

Future studies with longer follow-up and a dedicated needling-alone arm would help confirms whether this initial pain-relief benefit remains throughout the rehabilitation period and translates to a shorter overall rehabilitation period.

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