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Effect of Isometric Exercise on Pain and Range of Motion in Quadriceps Tendinopathy: A Case Report

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Abstract

Background: Quadriceps tendinopathy is a common overuse injury in athletes, characterized by pain, limited range of motion (ROM), and functional impairment. Isometric exercise has been proposed as a physiotherapy intervention that may reduce pain through endogenous analgesic mechanisms while maintaining neuromuscular activation without excessive mechanical loading.

Objective: To evaluate the clinical effect of isometric exercise on pain reduction and ROM improvement in a patient with quadriceps tendinopathy.

Methods: This study reports a single case (n=1) of a 14-year-old female taekwondo athlete diagnosed with quadriceps tendinopathy due to overuse. The intervention consisted of a structured isometric exercise program combined with supportive exercise therapy and cryotherapy, delivered over four sessions within two weeks. Pain intensity was measured using the Numeric Rating Scale (NRS), and ROM was assessed using a goniometer.

Results: Pain intensity decreased from 2/10 (rest), 7/10 (pressure), and 6/10 (movement) to 0/10, 3/10, and 3/10, respectively, indicating a reduction of 2–4 points, exceeding the minimal clinically important difference (MCID). Knee ROM improved from −5°–110° to −2°–125° on the affected side. Lower Extremity Functional Scale (LEFS) score improved from 63/80 to 72/80, reflecting enhanced functional capacity. Anthropometric measurements indicated a slight reduction in edema.

Conclusion: Isometric exercise may be a potentially effective intervention for reducing pain and improving ROM in quadriceps tendinopathy. However, these findings are preliminary, based on a single case, and cannot be generalized. Further studies with larger samples and controlled designs are required.

Keywords
Isometric Exercise; Quadriceps Tendinopathy; Pain Measurement; Range of Motion; Physical Therapy

Introduction

Quadriceps tendinopathy is a common overuse injury among athletes, particularly in sports involving repetitive jumping and high-intensity loading.[1] This condition is characterized by localized anterior knee pain, reduced range of motion (ROM), and functional limitations that may impair athletic performance.[1] Tendon overuse injuries are typically associated with cumulative mechanical stress exceeding tissue capacity, leading to microtrauma and inflammatory responses.

Exercise-based rehabilitation remains the cornerstone of tendinopathy management, with progressive tendon-loading programs widely recommended as first-line treatment due to their strong evidence base.[2] Various exercise modalities, including eccentric, concentric, and isometric training, have been explored, each demonstrating distinct physiological mechanisms and clinical outcomes.[3] Among these, eccentric exercise has traditionally been considered the gold standard due to its role in tendon remodeling and long-term functional recovery.[4] However, recent systematic reviews suggest that isometric and isotonic exercises may also provide significant pain reduction and functional improvement, although their comparative effectiveness remains inconclusive.[1]

Isometric exercise has gained increasing attention due to its ability to induce immediate analgesic effects without imposing excessive mechanical strain on injured tissues.[1] Experimental and clinical studies have demonstrated that isometric contractions can reduce tendon pain through exercise-induced hypoalgesia mechanisms.[1] These effects are mediated by activation of endogenous opioid systems, modulation of cortical inhibition, and improved neuromuscular control, which together contribute to pain reduction and functional recovery.[5,6] This analgesic effect is particularly relevant in early-stage rehabilitation, where pain limits the tolerance for dynamic loading exercises.

In addition to its analgesic properties, isometric exercise may facilitate neuromuscular activation and serve as an appropriate intervention during early-stage rehabilitation when dynamic loading is not yet tolerated.[1] Emerging evidence also suggests that combining isometric exercise with other modalities may enhance pain reduction and functional outcomes.[7] Despite these potential benefits, current evidence is largely derived from adult populations, with limited data specifically addressing adolescent athletes, who may exhibit different biomechanical and physiological responses to training stimuli.[1]

Furthermore, most available evidence originates from randomized controlled trials and systematic reviews, while detailed clinical observations from case reports remain limited, particularly in specific conditions such as quadriceps tendinopathy. This creates a gap in understanding individual responses to intervention in real-world clinical settings. Additionally, the potential interaction between isometric exercise and adjunctive interventions, such as cryotherapy, has not been clearly established, raising concerns regarding confounding effects in clinical outcomes.

From a clinical and methodological perspective, reporting individual cases remains important to provide context-specific insights, particularly in underrepresented populations such as adolescent athletes. Case reports contribute to early-stage evidence development and support hypothesis generation for future controlled studies.[8]

Therefore, this case report aims to describe the clinical response of an adolescent athlete with quadriceps tendinopathy to an isometric exercise intervention. Specifically, it evaluates changes in pain intensity and ROM following a short-term physiotherapy program. It is hypothesized that isometric exercise may contribute to clinically meaningful pain reduction and functional improvement, although the findings are expected to be context-specific and should be interpreted with caution.

Methods

This study employed a single-patient case report design in accordance with the CARE (CAse REport) guidelines to ensure transparent and standardized reporting of clinical findings and interventions. This study explicitly reports a single case (n=1).

The patient was a 14-year-old female taekwondo athlete who presented with anterior thigh pain during high-intensity training activities, particularly interval training. The symptoms had persisted for approximately one month and were associated with repetitive overuse. The patient reported a training frequency of approximately 4–5 sessions per week with high mechanical loading intensity. There was no history of direct trauma, systemic disease, or pharmacological treatment. Previous management consisted of temporary rest, which did not result in symptom improvement. Written informed consent was obtained from the patient and guardian prior to intervention.

Clinical examination revealed localized tenderness at the quadriceps tendon near the superior pole of the patella, mild edema, and reduced knee range of motion (ROM) on the affected side. Functional assessment using the Lower Extremity Functional Scale (LEFS) yielded a score of 63/80, indicating mild-to-moderate functional limitation. For interpretative context, a score closer to 80 represents normal lower extremity function. The LEFS has been widely reported as a valid and reliable instrument for assessing lower extremity function in musculoskeletal conditions.[9]

Pain intensity was assessed using the Numeric Rating Scale (NRS), which demonstrates high reliability and validity for clinical pain measurement.[10] ROM was measured using a standard goniometer with established reliability in joint angle assessment. Anthropometric measurements of knee circumference were performed using a measuring tape at standardized anatomical landmarks to monitor changes in edema.

The intervention consisted of a structured physiotherapy program in which isometric exercise served as the primary modality. Adjunct interventions, including supportive exercise therapy and cryotherapy, were clearly distinguished as secondary components to avoid misinterpretation of treatment effects. The program was delivered over four sessions within a two-week period, with a frequency of two sessions per week and a duration of 30–60 minutes per session.

The isometric exercise protocol targeted the quadriceps muscle and was performed within a pain-limited range. Each contraction was held for 10 seconds, with three sets of 10 repetitions per session. A rest interval of 30–60 seconds was provided between sets. Exercise intensity was progressed up to approximately 70% of perceived maximal voluntary contraction, monitored using patient-reported exertion and symptom response. Additional exercises included straight leg raise, hip abduction and adduction strengthening, calf raises, clamshell exercise, and static squat to support overall lower limb function.

Cryotherapy was applied using an ice pack at a temperature range of approximately 0–10°C for 10 minutes before and after exercise sessions. This modality was included as an adjunct intervention and considered a potential confounding factor during data interpretation.

Adherence to the intervention program was monitored through direct supervision during clinical sessions and patient self-report for home-based exercises, indicating good compliance throughout the intervention period. The patient also received education regarding activity modification, load management, and gradual return to sport. To provide a clear chronological overview of the intervention and evaluation process, the clinical timeline is presented in Table 1.

Table 1. Clinical Timeline of Intervention and Assessment

Time Point	Intervention and Assessment
Day 0	Baseline assessment: NRS, ROM, anthropometry, LEFS
Week 1 – Session 1	Isometric exercise + cryotherapy
Week 1 – Session 2	Isometric exercise + supportive exercise
Week 2 – Session 3	Progressive isometric exercise
Week 2 – Session 4	Final intervention session
Post-intervention	Outcome assessment: NRS, ROM, anthropometry, LEFS

Outcome measures were classified into primary and secondary outcomes. The primary outcome was pain intensity measured using the NRS. Secondary outcomes included ROM, anthropometric measurements reflecting edema changes, and functional status assessed using LEFS. Data analysis was performed descriptively by comparing pre- and post-intervention values, including absolute changes (delta values) in pain scores and ROM.

Clinical significance was interpreted based on established benchmarks, where a reduction of at least 2 points on the NRS was considered the minimal clinically important difference (MCID) for pain improvement.[10] No long-term follow-up assessment was conducted; therefore, the findings reflect short-term clinical outcomes only.

Ethical approval was not required for this case report according to institutional policy; however, written informed consent was obtained from the patient and guardian. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

The results are presented to describe changes in pain intensity, range of motion (ROM), anthropometric measurements, and functional status following a two-week physiotherapy intervention consisting of four sessions. The presentation focuses on objective comparisons between baseline and post-intervention assessments in accordance with the predefined primary and secondary outcomes. To provide a clear comparison of clinical outcomes before and after the intervention, the main findings are summarized in Table 2.

Table 2. Clinical Outcomes Before and After Intervention

Outcome	Baseline	Post-intervention	Absolute Change
NRS (rest)	2/10	0/10	−2
NRS (pressure)	7/10	3/10	−4
NRS (movement)	6/10	3/10	−3
ROM (knee dextra)	−5°–110°	−2°–125°	+3° extension, +15° flexion

LEFS	63/80	72/80	+9

As shown in Table 2, pain intensity decreased across all conditions, with the largest reduction observed in pressure pain (−4 points), followed by movement pain (−3 points) and resting pain (−2 points). ROM measurements demonstrated improvement in the affected knee (dextra), with an increase in flexion range of 15° and a reduction in extension limitation from −5° to −2°. No change was observed in the contralateral limb, which remained within normal limits throughout the intervention period. Functional assessment using LEFS demonstrated an improvement of 9 points, indicating enhanced lower extremity function following the intervention. To further describe changes in soft tissue condition, anthropometric measurements of knee circumference were recorded at predefined anatomical points. These data are summarized in Table 3.

Table 3. Anthropometric Measurements of Knee Circumference (cm)

Measurement Point	Baseline (Dextra)	Post-intervention (Dextra)	Change
20 cm above patella	49.2	48.5	−0.7
15 cm above patella	44.2	43.5	−0.7
10 cm above patella	42.3	41.5	−0.8
5 cm above patella	39.5	38.8	−0.7
Patella (0 cm)	37.0	36.5	−0.5
5 cm below patella	35.0	34.5	−0.5
10 cm below patella	36.0	35.5	−0.5
15 cm below patella	37.0	36.5	−0.5
20 cm below patella	33.0	32.8	−0.2

Anthropometric data indicate a consistent reduction in circumference across all measurement points on the affected limb, with changes ranging from −0.2 cm to −0.8 cm. To ensure clarity in the chronological sequence of intervention and outcome assessment, the evaluation process is summarized in Table 4.

Table 4. Clinical Timeline of Intervention and Outcome Assessment

Time Point	Description
Day 0	Baseline assessment: NRS, ROM, anthropometry, LEFS
Week 1 – Session 1	Isometric exercise + cryotherapy
Week 1 – Session 2	Isometric exercise + supportive exercise
Week 2 – Session 3	Progressive isometric exercise
Week 2 – Session 4	Final intervention session
Post-intervention	Outcome assessment: NRS, ROM, anthropometry, LEFS

All outcomes were assessed consistently at baseline and after completion of the fourth intervention session. No adverse events were reported during the intervention period.

Discussion

The present case report demonstrated a reduction in pain intensity and an improvement in range of motion (ROM) and functional status following a short-term isometric exercise intervention in an adolescent athlete with quadriceps tendinopathy. The observed decrease in pain scores across resting, pressure, and movement conditions exceeded the commonly accepted minimal clinically important difference (MCID), indicating a clinically meaningful response.[10] These findings are consistent with previous evidence suggesting that isometric exercise can induce short-term analgesic effects in individuals with tendinopathy.[1]

The analgesic response observed in this case may be explained through the mechanism of exercise-induced hypoalgesia, which involves activation of descending inhibitory pathways within the central nervous system.[11] Isometric contractions have been shown to reduce tendon pain immediately after exercise, likely through modulation of cortical inhibition and altered motor cortex excitability.[1] Furthermore, these effects are associated with activation of endogenous opioid systems and neuromodulatory processes that influence pain perception.[11] These mechanisms are particularly relevant in early-stage rehabilitation, where pain reduction is necessary to facilitate tolerance to subsequent loading interventions.

In addition to pain reduction, the improvement in ROM and functional status, as reflected by the increase in LEFS score, may be attributed to reduced muscle guarding and enhanced neuromuscular activation. The reduction in nociceptive input may facilitate improved motor unit recruitment and joint mobility, thereby contributing to functional recovery. This finding aligns with previous studies reporting that exercise-based interventions improve functional outcomes in tendinopathy through both peripheral and central adaptations.[3]

However, these findings should be interpreted within the broader context of comparative evidence. While isometric exercise appears effective for short-term pain relief, several systematic reviews suggest that it may not be superior to other loading strategies, such as eccentric or isotonic exercise, particularly for long-term outcomes.[4,12] Eccentric loading has been widely recognized as a key component of tendon rehabilitation due to its role in promoting tendon remodeling and structural adaptation. Therefore, isometric exercise may be more appropriately positioned as an early-phase or adjunct intervention rather than a standalone long-term treatment strategy.[1]

The present case also highlights the potential influence of adjunctive interventions. Cryotherapy was administered alongside isometric exercise, which introduces a possible confounding effect. Although cryotherapy is commonly used to manage pain and inflammation, its independent contribution to clinical improvement remains unclear. Consequently, the observed outcomes cannot be attributed solely to isometric exercise, and the interaction between interventions should be interpreted with caution.

From a methodological perspective, several sources of bias inherent to case report design must be acknowledged. Natural recovery may contribute to symptom improvement, particularly in overuse injuries with relatively short duration. In addition, placebo effects and patient expectations may influence subjective outcomes such as pain perception. The absence of a control condition further limits causal inference and generalizability.

Another important consideration is external validity. Most available evidence on isometric exercise has been derived from adult populations, whereas this case involves an adolescent athlete.[1] Differences in tissue adaptation, training load, and recovery capacity may influence treatment response in younger individuals. Therefore, the findings of this case report should not be generalized beyond similar clinical contexts.

Despite these limitations, this case provides clinically relevant insight into the application of isometric exercise in an underrepresented population. The case is considered noteworthy due to its focus on an adolescent athlete with quadriceps tendinopathy, a population for which clinical evidence remains limited. Such reports contribute to the development of individualized rehabilitation strategies and support hypothesis generation for future research.

From a clinical perspective, isometric exercise may be considered a feasible and safe initial intervention for pain modulation, particularly when dynamic loading is not well tolerated.[1] It may serve as a bridging strategy before progression to more intensive loading programs, such as eccentric or progressive resistance training. Clinicians should integrate this approach within a comprehensive rehabilitation framework tailored to patient-specific needs.

This study has several limitations. The short duration of intervention restricts the ability to evaluate long-term outcomes, and no follow-up assessment was conducted. The combined intervention approach limits the ability to isolate the specific contribution of isometric exercise. Additionally, the absence of patient-reported perspective limits insight into subjective treatment experience.

Future research should employ controlled study designs, larger sample sizes, and longer follow-up periods to determine the effectiveness and optimal application of isometric exercise in tendinopathy management.

Conclusion

This case report demonstrates that isometric exercise may contribute to short-term pain reduction and improvement in range of motion (ROM) and functional status in an adolescent athlete with quadriceps tendinopathy. The observed reduction in pain exceeded the minimal clinically important difference, indicating a clinically meaningful response within the intervention period.

However, these findings are preliminary, derived from a single case (n=1), and cannot be generalized to broader populations. The concurrent use of adjunctive interventions, such as cryotherapy, and the absence of long-term follow-up limit the ability to establish causal relationships and sustained effectiveness.

From a clinical perspective, isometric exercise may be considered a feasible early-stage intervention for pain modulation, particularly when dynamic loading is not well tolerated. It may serve as an initial or bridging strategy before progression to more intensive loading programs, such as eccentric or progressive resistance training.

Future research should focus on controlled study designs with larger sample sizes, inclusion of adolescent populations, and longer follow-up periods to better determine the effectiveness and optimal application of isometric exercise in tendinopathy management.

Author Contribution

Layla Widad Jamil: Conceptualization, Data curation, Writing original draft, Writing review and editing.
Suryo Saputra Perdana: Conceptualization, Data curation.
Sigit Saputro: Conceptualization, Data curation.

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Patient Perspective

The patient reported a reduction in pain during training activities and expressed increased confidence in performing lower limb movements following the intervention. The patient also reported improved comfort during daily activities and gradual return to sport-specific exercises.

Conflict of Interest Statement

The authors declare that there is no conflict of interest related to this case report.

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This case report received no external funding.

Ethics Statement

Written informed consent was obtained from the patient for participation in the case report and publication of relevant clinical information. The case report was conducted in accordance with the ethical principles of the Declaration of Helsinki. No personally identifiable information of the patient is disclosed in this manuscript.

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