

## EFFECT OF SINGLE-LEG MINI-SQUATS COMBINED WITH KNEE ISOMETRICS ON PATIENTS WITH GRADE 1 CHONDROMALACIA PATELLAE

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### ABSTRACT

**Background** Chondromalacia patellae is a common cause of anterior knee pain, particularly in young and active individuals. Early-stage management focuses on conservative physiotherapy interventions aimed at pain reduction and muscle strengthening to prevent disease progression. **Objective:** To determine the effect of single-leg mini-squats combined with knee isometric exercises on pain intensity and quadriceps muscle strength in patients with Grade I chondromalacia patellae. **Methods:** A pre-experimental single-group pre-test and post-test study design was used. Thirty patients diagnosed with Grade I chondromalacia patellae participated in a six-week exercise intervention consisting of single-leg mini-squats and knee isometric exercises. Pain intensity was measured using the Visual Analogue Scale, and quadriceps strength was assessed using Manual Muscle Testing. Pre- and post-intervention data were analyzed using paired t-test and one-sample t-test. **Results:** The results demonstrated a statistically highly significant reduction in pain scores and a significant improvement in quadriceps muscle strength following the intervention ( $p < 0.001$ ). One-sample t-test confirmed that the mean changes in pain and muscle strength were significantly greater than zero, indicating a true treatment effect. **Conclusion:** Single-leg mini-squats combined with knee isometric exercises are effective in reducing pain and improving quadriceps strength in patients with Grade I chondromalacia patellae. This exercise protocol can be safely incorporated into physiotherapy rehabilitation programs for early-stage anterior knee pain.

**KEYWORDS:** *Chondromalacia patellae, anterior knee pain, single-leg mini-squat, knee isometrics, physiotherapy rehabilitation.*

## INTRODUCTION

Chondromalacia patellae is one of the most common causes of anterior knee pain, particularly affecting young adults and physically active individuals. It is characterized by softening, fissuring, or degeneration of the articular cartilage on the posterior surface of the patella, leading to pain, discomfort, and functional limitations during activities such as squatting, stair climbing, prolonged sitting, and running. The condition is frequently encountered in clinical physiotherapy practice and poses a significant challenge due to its recurrent nature and potential progression if not managed appropriately.

The etiology of chondromalacia patellae is multifactorial and includes abnormal patellofemoral joint mechanics, quadriceps muscle weakness, muscular imbalance, altered lower limb alignment, and impaired neuromuscular control. Among these factors, weakness of the quadriceps muscle—particularly poor control during functional activities—has been identified as a major contributor to increased patellofemoral joint stress and altered patellar tracking. In early stages of the condition, especially Grade I chondromalacia patellae, conservative management remains the treatment of choice, with physiotherapy playing a pivotal role in symptom management and functional restoration.

Exercise therapy is widely recognized as the cornerstone of conservative management for chondromalacia patellae. Strengthening of the quadriceps muscle helps improve patellar stability, reduce joint stress, and enhance functional performance. Closed kinetic chain exercises have gained particular attention due to their ability to promote co-contraction of surrounding musculature, improve proprioception, and mimic functional movement patterns while reducing excessive shear forces at the knee joint. Among these, squatting exercises are considered highly functional and effective in addressing deficits associated with anterior knee pain.

Single-leg mini-squats represent a progression of traditional squatting exercises and place greater demands on neuromuscular control, balance, and lower limb alignment. Performing squats on a single limb challenges the dynamic stability of the knee joint and helps correct faulty movement patterns such as dynamic valgus, which is commonly associated with patellofemoral pain. Additionally, limiting the squat depth to a mini-squat range minimizes patellofemoral joint stress, making it suitable for patients with early-stage chondromalacia patellae.

Isometric exercises for the knee, particularly quadriceps isometric contractions, are commonly used in the early phases of rehabilitation to improve muscle activation and strength while minimizing joint movement and pain. Isometric strengthening has been shown to reduce pain through neuromodulatory mechanisms and improve muscle recruitment without exacerbating symptoms. When combined with functional exercises, isometric training may enhance the overall effectiveness of rehabilitation by addressing both strength deficits and functional impairments.

Despite the widespread use of various exercise protocols in the management of chondromalacia patellae, there remains limited evidence specifically examining the combined effect of single-leg mini-squats and knee isometric exercises in patients with Grade I chondromalacia patellae. Understanding the effectiveness of this combined intervention may provide valuable insights into optimizing early-stage rehabilitation strategies and preventing disease progression.

Therefore, the present study was undertaken to evaluate the effect of single-leg mini-squats combined with knee isometric exercises on pain intensity and quadriceps muscle strength in patients with Grade I chondromalacia patellae.

## **METHODOLOGY**

### **Study Design**

The present study will adopt a pre-experimental (single group pre-test and post-test) design to evaluate the effect of single-leg mini-squats combined with knee isometric exercises on patients diagnosed with Grade I chondromalacia patellae.

### **Study Setting**

The study will be conducted in the **Physiotherapy Outpatient Department** of a tertiary care hospital/physiotherapy clinic.

### **Study Duration**

The total duration of the study will be 6 weeks, including pre-intervention assessment, intervention period, and post-intervention assessment.

### **Sample Size**

A total of 30 participants diagnosed with Grade I chondromalacia patellae will be selected using convenience sampling.

### **Sampling Method**

Participants will be recruited through non-probability convenience sampling from the outpatient department.

### **Selection Criteria**

#### **Inclusion Criteria**

- Male and female participants aged 18–40 years
- Clinically and radiologically diagnosed Grade I chondromalacia patellae
- Presence of anterior knee pain aggravated by activities such as squatting, stair climbing, or prolonged sitting
- Willingness to participate and provide informed consent

#### **Exclusion Criteria**

- Grade II, III, or IV chondromalacia patellae
- History of knee surgery or traumatic knee injury
- Presence of ligament injuries, meniscal tears, or patellar instability
- Neurological disorders affecting lower limb function
- Inflammatory joint diseases or acute knee inflammation

### **Outcome Measures**

- **Pain intensity** – Visual Analogue Scale (VAS)
- **Muscle strength** – Manual Muscle Testing (MMT) for quadriceps

Assessments will be performed **before and after the intervention period**.

### **Intervention Protocol**

#### **Single-Leg Mini-Squats**

- Performed on the affected limb
- Knee flexion range: **0–45 degrees**
- Participant instructed to maintain neutral pelvic and knee alignment
- **3 sets of 10 repetitions**
- Progression based on pain tolerance and control

#### **Knee Isometric Exercises**

- **Quadriceps isometric contractions** performed in supine or sitting
- Hold time: **5–10 seconds**

- 10 repetitions per set
- 3 sets per session

**Frequency and Duration**

- Exercises will be performed 5 sessions per week
- Each session lasting 30–40 minutes
- Total intervention period: 6 weeks

**Procedure**

1. Participants fulfilling the inclusion criteria will be informed about the study.
2. Written informed consent will be obtained.
3. Baseline assessment of pain, function, and muscle strength will be recorded.
4. Participants will undergo the intervention protocol for 6 weeks.
5. Post-intervention assessment will be conducted using the same outcome measures.

**Data Analysis**

- Pre- and post-intervention data will be analyzed using **paired t-test**.
- Statistical analysis will be performed using **SPSS software**.
- A **p-value < 0.05** will be considered statistically significant.

**RESULTS**

**Table 1: Descriptive statistics of VAS and MMT scores in the experimental group.**

Variable	N	Mean	Std. Deviation
VAS (Pre-test)	30	7.13	1.15
VAS (Post-test)	30	3.47	1.06
MMT (Pre-test)	30	3.40	0.49
MMT (Post-test)	30	4.57	0.50

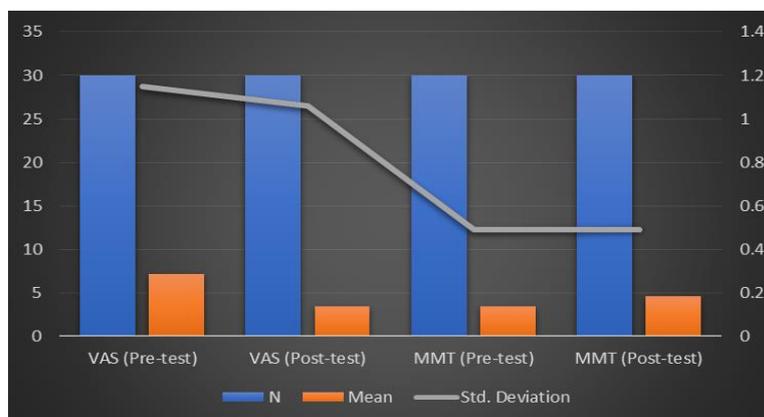


Table 1 presents the descriptive statistics of pain intensity and quadriceps muscle strength in the experimental group. The mean pre-test VAS score was high, indicating moderate to severe anterior knee pain among participants prior to intervention. Following the intervention, a marked reduction in mean VAS score was observed, reflecting a clinically meaningful decrease in pain. Similarly, the mean pre-test MMT score demonstrated reduced quadriceps strength at baseline, while the post-test mean showed a noticeable improvement in muscle strength. The relatively low standard deviation values in both pre- and post-test scores suggest consistency in response to the intervention across participants.

**Table 2: Paired samples statistics of pre- and post-intervention values.**

Variable Pair	Mean	Std. Deviation	Std. Error Mean
VAS Pre-test	7.13	1.15	0.21
VAS Post-test	3.47	1.06	0.19
MMT Pre-test	3.40	0.49	0.09
MMT Post-test	4.57	0.50	0.09

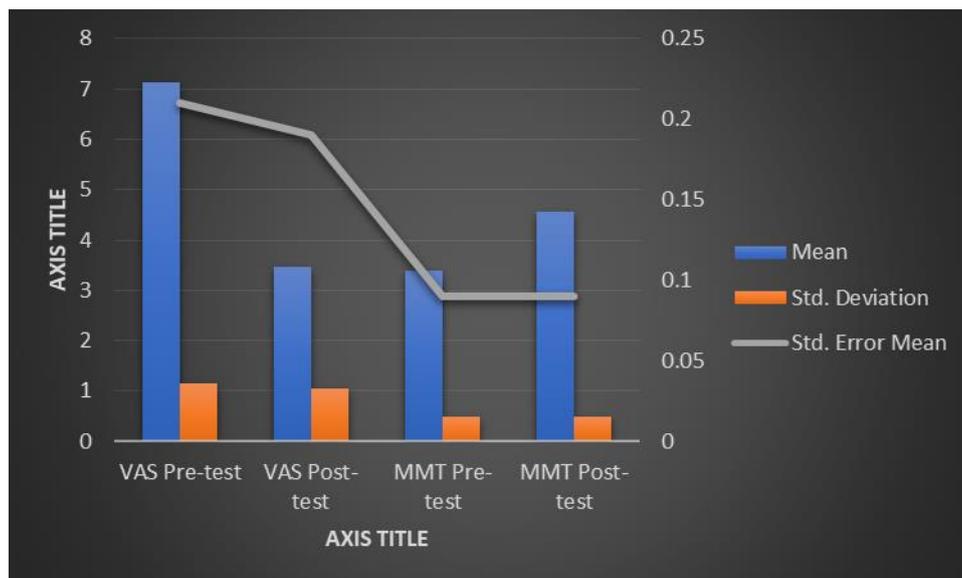


Table 2 illustrates the paired samples statistics for pre- and post-intervention measures of VAS and MMT. The mean difference between pre- and post-test values indicates a substantial reduction in pain scores and a corresponding increase in quadriceps strength after the intervention period. The standard error of the mean for both outcome measures is minimal, suggesting reliable mean estimates and stability of the data. This pattern highlights a uniform trend of improvement among participants following the exercise intervention.

**Table 3: Comparison of pre- and post-test values using paired t-test.**

Variable	Mean Difference	Std. Deviation	t value	df	p value
VAS (Pre vs Post)	3.67	1.63	12.35	29	< 0.001*
MMT (Pre vs Post)	-1.17	0.69	-9.14	29	< 0.001*

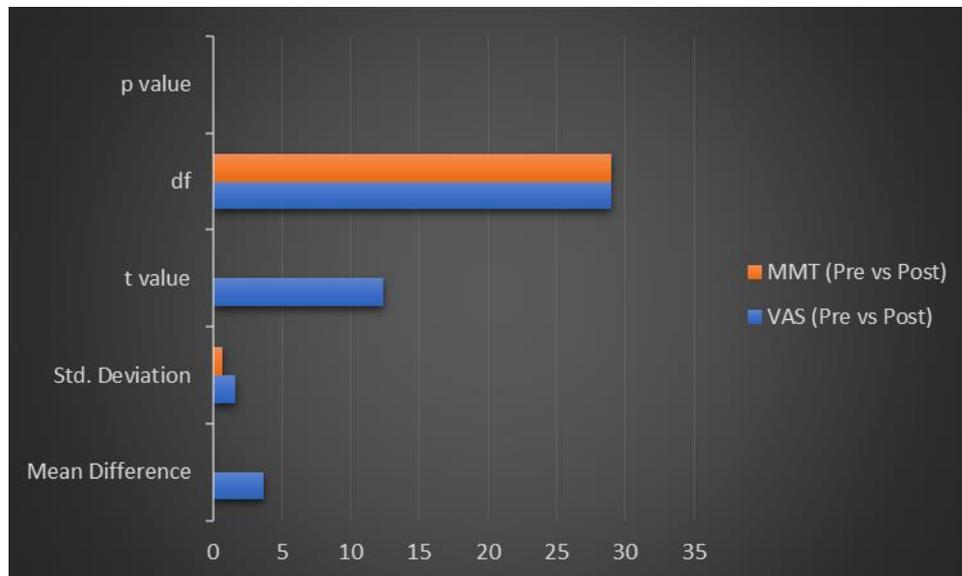


Table 3 depicts the results of the paired samples t-test comparing pre- and post-intervention scores within the experimental group. The analysis revealed a statistically highly significant reduction in VAS scores and a statistically significant improvement in MMT scores following the intervention, with p values less than 0.001. These findings indicate that the observed changes in pain reduction and muscle strength enhancement were not due to chance. Therefore, the intervention of single-leg mini-squats combined with knee isometric exercises was effective in producing significant therapeutic improvements in patients with Grade I chondromalacia patellae.

**Table 4: One-sample t-test comparing mean change scores against zero.**

Variable	Mean Difference	Std. Deviation	t value	df	p value
VAS Change Score	3.67	1.63	12.35	29	< 0.001*
MMT Change Score	1.17	0.69	9.14	29	< 0.001*

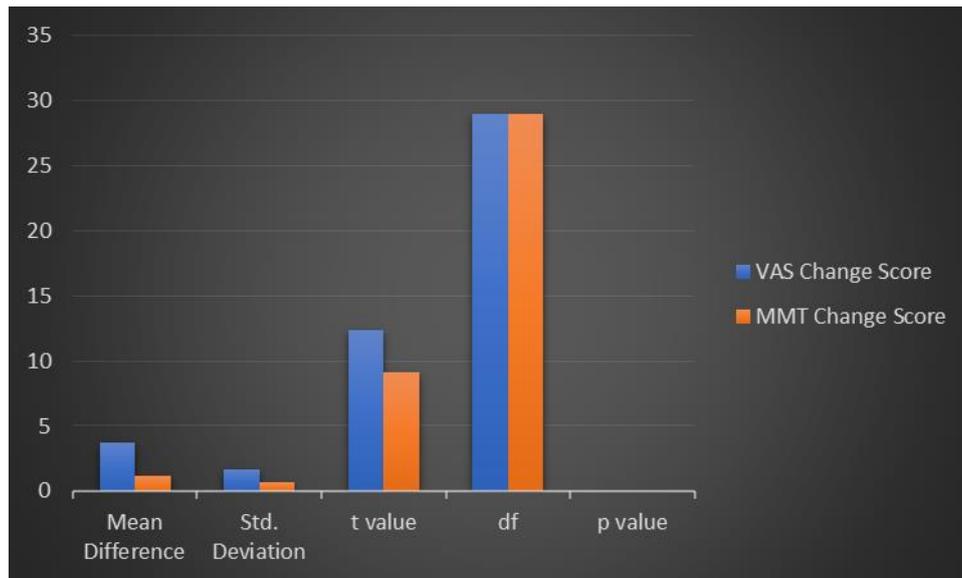


Table 4 presents the results of the one-sample t-test conducted on the mean change scores of VAS and MMT, using a test value of zero. The statistically significant results demonstrate that the mean reduction in pain and mean improvement in muscle strength were significantly greater than zero. This confirms the presence of a true treatment effect and further validates the effectiveness of the intervention in improving clinical outcomes in the experimental group.

### Result Interpretation

The overall results of the study demonstrate that the intervention comprising single-leg mini-squats combined with knee isometric exercises led to significant improvements in both pain and quadriceps muscle strength among patients with Grade I chondromalacia patellae. The consistent reduction in VAS scores and enhancement in MMT scores across participants indicate that the intervention was both effective and reliable. Statistical analyses using paired t-test and one-sample t-test confirmed that these improvements were statistically highly significant. These findings suggest that incorporating functional closed-chain exercises along with isometric strengthening can be an effective rehabilitation strategy for early-stage chondromalacia patellae.

### DISSCUSSION

The present study was conducted to determine the effectiveness of single-leg mini-squats combined with knee isometric exercises on pain intensity and quadriceps muscle strength in patients with Grade I chondromalacia patellae. The results of the study demonstrated a statistically highly significant reduction in pain and a significant improvement in quadriceps

muscle strength following the intervention, indicating the effectiveness of the selected exercise protocol.

The significant reduction in VAS scores observed in the experimental group may be attributed to improved patellofemoral joint mechanics achieved through closed kinetic chain exercises such as single-leg mini-squats. These exercises promote co-contraction of the quadriceps and hamstrings, thereby reducing excessive patellofemoral joint stress and improving patellar tracking. Previous studies have reported that controlled closed-chain exercises reduce anterior knee pain by enhancing neuromuscular control and distributing joint loads more evenly across the patellofemoral joint. The findings of the present study are consistent with those reported by **Witvrouw et al.** and **Escamilla et al.**, who highlighted the benefits of functional weight-bearing exercises in managing patellofemoral pain syndromes.

The improvement in quadriceps muscle strength, as evidenced by increased MMT scores, can be attributed to the incorporation of knee isometric exercises alongside functional squatting movements. Isometric exercises are known to enhance muscle activation while minimizing joint movement, making them particularly beneficial in early-stage chondromalacia patellae where excessive joint loading must be avoided. Previous research by **Crossley et al.** and **Bennell et al.** demonstrated that quadriceps strengthening plays a crucial role in reducing patellofemoral pain and improving knee function, especially in the early stages of cartilage degeneration.

Single-leg mini-squats further challenge balance and proprioception, leading to improved lower limb alignment and neuromuscular control. Improved control of dynamic valgus during single-leg tasks has been strongly associated with reduced patellofemoral joint stress. Studies by **Powers** and **Earl et al.** have emphasized the importance of single-leg functional exercises in correcting faulty movement patterns and reducing anterior knee pain. The present study supports these findings by demonstrating functional and symptomatic improvements following a single-leg exercise-based intervention.

The statistically significant findings from the one-sample t-test further confirm that the observed improvements were genuine treatment effects rather than random variations. The consistency of improvements across participants suggests that the intervention protocol was effective and well tolerated. Overall, the results of the present study align with existing literature supporting the use of functional strengthening and isometric exercises in the conservative management of early-stage chondromalacia patellae.

## **CLINICAL IMPLICATIONS**

The findings of this study have important clinical implications for physiotherapy practice. Single-leg mini-squats combined with knee isometric exercises can be safely and effectively incorporated into rehabilitation programs for patients with Grade I chondromalacia patellae. This exercise protocol is simple, cost-effective, and requires minimal equipment, making it feasible for both clinical and home-based rehabilitation settings. Early implementation of such targeted strengthening and functional exercises may help reduce pain, improve quadriceps strength, and potentially prevent progression to advanced stages of chondromalacia patellae. Physiotherapists can utilize this approach to enhance functional outcomes and promote long-term knee joint health in individuals with anterior knee pain.

## **LIMITATIONS OF THE STUDY**

Despite the positive findings, the present study has certain limitations. The absence of a control group limits the ability to compare the effectiveness of the intervention against conventional treatment or no intervention. The study included a relatively small sample size, which may affect the generalizability of the results. Muscle strength was assessed using Manual Muscle Testing, which, although clinically useful, is subjective and less sensitive compared to objective measures such as isokinetic dynamometry. Additionally, the study focused only on short-term outcomes, and long-term follow-up was not conducted to assess the sustainability of improvements.

## **FUTURE SCOPE**

Future studies should include randomized controlled trials with larger sample sizes to strengthen the evidence for the effectiveness of this intervention. The inclusion of a control group or comparison with other exercise protocols would provide a clearer understanding of relative treatment efficacy. Future research may also incorporate objective outcome measures such as electromyography or isokinetic testing to assess muscle activation and strength more precisely. Long-term follow-up studies are recommended to determine whether early intervention with functional and isometric exercises can prevent disease progression and recurrence of symptoms in patients with chondromalacia patellae.

## **CONCLUSION**

The present study concluded that single-leg mini-squats combined with knee isometric exercises are effective in reducing pain and improving quadriceps muscle strength in patients with Grade I chondromalacia patellae. Statistically highly significant improvements were

observed in both pain intensity and muscle strength following the intervention period. The findings support the use of functional closed kinetic chain exercises along with isometric strengthening as a conservative and effective physiotherapeutic approach for early-stage chondromalacia patellae. Early intervention using such targeted exercise protocols may help in symptom relief, functional improvement, and prevention of disease progression.

## **SUMMARY**

This study was undertaken to evaluate the effect of single-leg mini-squats combined with knee isometric exercises on pain and quadriceps muscle strength in patients with Grade I chondromalacia patellae. Thirty participants meeting the inclusion criteria were recruited using convenience sampling and underwent a structured exercise intervention for six weeks. Pain intensity was assessed using the Visual Analogue Scale, and muscle strength was evaluated using Manual Muscle Testing.

Statistical analysis using paired t-test and one-sample t-test revealed statistically highly significant reductions in pain and significant improvements in quadriceps strength following the intervention. The results suggest that functional closed-chain exercises combined with isometric strengthening are effective in managing early-stage chondromalacia patellae. The study highlights the importance of incorporating functional and strengthening exercises in physiotherapy rehabilitation programs for anterior knee pain.

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