ISSN: 2347-6567

International Journal of Allied Medical Sciences and Clinical Research (IJAMSCR)

IJAMSCR |Vol. 14 | Issue 4| Oct - Dec 2026

www.ijamscr.com

DOI : https://doi.org/10.61096/ijamscr.v14.iss4.2026.1801-1807

Effect of Gluteus Maximus Strengthening in Genu Recurvatum: Pre-Experimental Study

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Published on: 21-10-2026
Published by: Futuristic Publications
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Abstract

Background: Genu recurvatum [GR] refers to knee joint deformity with extension of the knee greater than 5 degrees. The aetiology of genu recurvatum is divided into congenital, constitutional, or acquired genu recurvatum. The genu recurvatum angle is associated with weaker hip external rotation (HER) muscle strength relative to hip internal rotation (HIR) muscle strength. The deformity is typically attributed to the functional weakness of the gluteus maximus. Gluteus maximus is the largest muscle in the buttocks. Its primary function is to extend the thigh and externally rotate the thigh.

Objectives: The study aims to find the effect of gluteus maximus strengthening on improving genu recurvatum.

Methods: This pre-experimental study was conducted in the Exercise Therapy Laboratory of Revathi Institute of Physiotherapy over a duration of eight months. A total of 30 participants were selected using purposive sampling. Subjects aged between 18 and 30 years, of both genders, with knee hyperextension greater than 5 degrees were included. Participants attended physiotherapy sessions twice a week for a total of 10 visits, with each session lasting approximately 30 minutes. The genu recurvatum angle was assessed using a universal goniometer in supine lying, with knee extension sustained using a towel. The stationary arm of the goniometer was aligned from the lateral epicondyle to the greater trochanter of the femur, and the movable arm from the lateral epicondyle to the lateral malleolus of the fibula, while the subject actively extended the knee.

Result: On comparing mean values of Genu Recurvatum Knee ROM between Pretest 6.10 ± .803 and Posttest 5.20 ± .761 within the group, it shows there is a highly significant difference between the pre-test and Post-test mean values, with a t value of 10.25 at $P \leq 0.001$. The Post-test values have shown improvement when compared with the pre-test. Hence, the null hypothesis is rejected.

Conclusion: The results of the study showed a statistically significant improvement in knee range of motion with a reduction in genu recurvatum angle following gluteus maximus strengthening exercises. Comparison of pre-test and post-test measurements demonstrated a noticeable decrease in knee hyperextension among the participants. The findings indicate that the intervention was effective in improving knee control and alignment in individuals with genu recurvatum.

Key Words: Genu Recurvatum, Gluteus maximus muscle strengthening

Introduction:

The knee joint is the largest and one of the most complex joints in the human body. Its stability is provided by static and dynamic structures, including the joint capsule, collateral and cruciate ligaments, menisci, and surrounding musculature. Among the dynamic stabilizers, the quadriceps, hamstrings, gastrocnemius, popliteus, pes anserinus, and iliotibial band contribute to maintaining knee alignment and stability during functional activities such as walking and running. The gluteus maximus, the primary extensor and a powerful external rotator of the hip, also contributes to pelvic and trunk stability and indirectly supports knee stability through its attachment to the iliotibial tract.[1,4]

The gluteus maximus originates from the posterior ilium, sacrum, coccyx, sacrotuberous ligament, and thoracolumbar fascia, and inserts into the iliotibial tract and gluteal tuberosity of the femur. It plays an important biomechanical role during weight-bearing and gait by generating hip extension torque, maintaining pelvic stability, controlling trunk movement, and contributing to lower-limb alignment. Through its attachment to the iliotibial tract, the muscle also assists in lateral knee stability and regulation of knee movement.[2,3,5]

Genu recurvatum is characterized by excessive hyperextension of the knee, generally defined as hyperextension greater than 5° in the sagittal plane. It may be congenital or acquired, with acquired causes including trauma, cerebrovascular accident, poliomyelitis, physeal arrest, Osgood-Schlatter disease, and prolonged casting. Functionally, genu recurvatum may be associated with weakness of the quadriceps, knee flexors, and gastrocnemius, gastrocnemius spasticity, and impaired proprioception or motor control.[7,9,10]

During standing and walking, the ground reaction force may pass anterior to the knee joint, producing an extension moment that can contribute to hyperextension. Weakness of the posterior stabilizing muscles, particularly the hamstrings and gastrocnemius–soleus complex, may reduce the ability to control terminal knee extension and tibial movement. Similarly, gluteus maximus weakness may reduce hip extension and pelvic stability, promote anterior pelvic tilt and compensatory knee hyperextension, and consequently influence lower-limb biomechanics.[1,9,16]

Clinical manifestations of genu recurvatum may include pain, weakness, instability, leg-length discrepancy, and restricted range of motion. Assessment includes gait and alignment analysis, ligament assessment, range-of-motion measurement, and appropriate special tests, while radiographic investigations may be used to evaluate bony alignment and structural abnormalities. Conservative physiotherapy management includes strengthening, proprioceptive and neuromuscular training, gait re-education, stretching, and activity modification, with orthotic or surgical management considered according to severity and underlying pathology.[9,13,14]

Previous studies have suggested that reduced gluteus maximus strength may alter lower-limb biomechanics and contribute to genu recurvatum. Strengthening the gluteus maximus may improve hip extension, pelvic and proximal stability, lower-limb alignment, and control of hip and knee movements during gait, thereby reducing compensatory knee hyperextension. In addition, an association has been reported between increased genu recurvatum angle and reduced gluteus maximus strength, highlighting the potential role of this muscle in knee stability.[15]

However, there is limited evidence specifically examining the effect of a structured gluteus maximus strengthening programme on genu recurvatum. Therefore, the present study aims to investigate the effect of a structured gluteus maximus strengthening programme on genu recurvatum and to determine its potential role in improving knee alignment and functional stability.

Methods:

Study design: A pre-experimental study was conducted in an exercise therapy laboratory over a period of eight months. Ethical approval was obtained from the Institutional Ethics Committee (Approval No. RIPR/DT/21/4527). Written informed consent was obtained from all participants before enrolment. The study was conducted in accordance with institutional ethical standards.

Participants: A total of 30 participants were selected using purposive sampling. Subjects aged between 18 and 30 years, of both genders, with knee hyperextension greater than 5 degrees were included. Participants attended physiotherapy sessions twice a week for a total of 10 visits, with each session lasting approximately 30 minutes. The genu recurvatum angle was assessed using a universal goniometer in supine lying, with knee extension sustained using a towel.

Eligibility criteria

Inclusion Criteria

The study included participants aged 18 to 30 years, of both male and female genders, who had more than 5° of knee extension. Participants with bilateral or unilateral genu recurvatum were included in the study. Only subjects who were willing to participate in the study and provided informed consent were recruited

Exclusion Criteria

Participants with a ligament or meniscal injury within the previous year, fractures of the femur, tibia, patella, or lower back, and those with excessive knee pain (NPRS >3) were excluded. Subjects with neurological conditions, arthritis of the hip or knee, previous hip or knee surgery, or joint hypermobility (Beighton score >5) were also excluded.

Intervention: The gluteus maximus strengthening program comprised bilateral bridge, unilateral bridge, quadruped hip abduction, standing hip extension with anterior support, and deadlift exercises. Exercises were performed with emphasis on proper posture, neutral spinal and pelvic alignment, controlled movements, and active gluteal muscle contraction. The bridge exercises involved lifting the pelvis through hip extension and maintaining the position for 3–5 seconds, while quadruped hip abduction was performed with the knee flexed and held for 2–3 seconds. Standing hip extension was performed within a pain-free range while avoiding compensatory lumbar extension and pelvic rotation. Deadlifts were performed using a hip-hinge movement while maintaining a neutral spine and engaging the gluteal and hamstring muscles during the return to standing.

Outcome measures

RANGE OF MOTION - GONIOMETER

In this study Genu recurvatum angle is used as an outcome measure, and a goniometer is used as a tool. The goniometer is an instrument used to measure the degree of hyperextension of the knee; it has both interrater and intrarater reliability in measuring knee joint range of motion for the genu recurvatum angle.

Statistical analysis

All the parameters were assessed using the Statistical Package for social science (SPSS) version 24, with a significance level of p-value less than 0.05 and a 95% confidence interval set for all analyses. The Shapiro-Wilk test was used to determine the normality of the data. In this study, the Shapiro-Wilk test showed that the data were normally distributed in the dependent variables at $P > 0.05$. Hence parametric test was adopted. Paired t-test was adopted to find the statistical difference within the groups.

Results

Thirty (30) subjects with genu recurvatum were selected using purposive sampling. The knee range of motion was assessed before and after the intervention program of gluteus maximus strengthening exercises.

Analysis of dependent variables of Genu Recurvatum Knee ROM within the Group:

The calculated paired t value was 10.25, and the level of significance was $P \leq 0.001$. Since the calculated t value was statistically significant, there was a significant improvement in knee range of motion following gluteus maximus strengthening exercises.

When comparing the mean values of Pre-test and Post-test, it was observed that there was a statistically significant improvement in the post-test values.

On comparing the Mean Values of Genu Recurvatum Knee ROM between Pre-test and Post-test, it shows a significant decrease in the post-test mean values. The Pre-test mean value was 6.10 ± 0.803, whereas the Post-test mean value was 5.20 ± 0.761 at $P \leq 0.001$. The lower post-test mean value indicates improvement in knee alignment and reduction in genu recurvatum following gluteus maximus strengthening exercises.

On comparing Pre-test and Post-test values within the group, it shows a highly significant difference in the mean values at $P \leq 0.001$. Hence, the null hypothesis is rejected.

Table 1: Comparison of Genu Recurvatum Knee Rom within Group Between Pre-Test and Post-Test Values

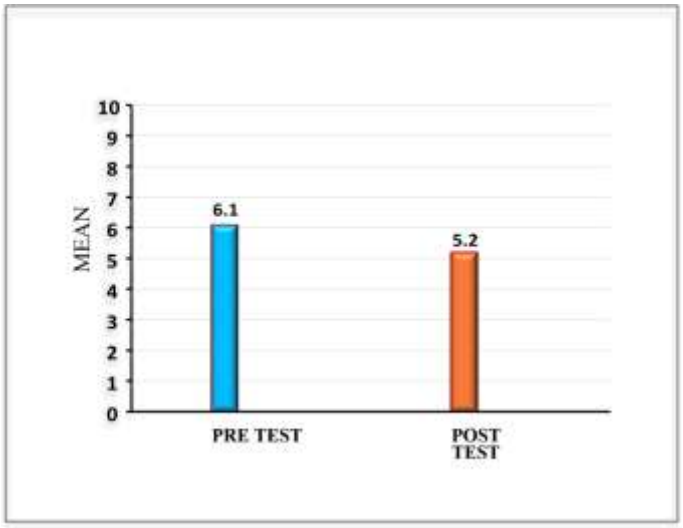
TEST	PRE-TEST		POST-TEST		t- test	df	Sig
	MEAN	S.D	MEAN	S.D			
KNEE ROM	6.10	.803	5.20	.761	10.25	29	.001***

(***- P ≤ 0.001 - Significant).

The above table reveals the Mean, Standard Deviation (S.D.), t - test, degrees of freedom (df), and p-value between the pre-test and post-test.

There is a statistically significant difference between the pre-test and post-test values within the group at P ≤ 0.001.

Graph 1: Comparison of Genu Recurvatum Knee Rom Within Group Between Pre-Test And Post-Test Values



Discussion

The study results showed that gluteus maximus strengthening resulted in a 14.8% reduction in genu recurvatum angle among subjects with genu recurvatum.

The present study was designed as a pre-experimental study and was conducted in the Exercise Therapy Laboratory of Revathi Institute of Physiotherapy. The study was carried out over a duration of eight months. A total of 30 participants were selected using purposive sampling. The intervention program consisted of physical therapy sessions conducted twice per week for a total of 10 sessions, with each session lasting approximately 30 minutes. Participants included both male and female subjects aged between 18 and 30 years who demonstrated more than 5 degrees of knee extension indicative of genu recurvatum.

The gluteus maximus plays an essential role in maintaining upright posture, controlling femoral motion, and stabilizing the pelvis and knee through its attachment to the iliotibial band. Weakness of this muscle may result in excessive anterior pelvic tilt, increased hip flexion moment, and compensatory knee hyperextension. the present study further extends these findings by demonstrating that targeted gluteus maximus strengthening can reduce the genu recurvatum angle by 14.8%, thereby providing interventional evidence for its clinical effectiveness.

As with most research projects, it may have encountered certain methodological biases. This study also encountered some biases, such as sample allocation bias has been neglected due to unintentional random allocation of samples. Another commonly occurring bias is data collection bias, which has been mitigated by using valid measurement tools and proper measurement techniques; data collector bias has not influenced or expected any result while collecting the data, and the data were cross verified by my research fellows.

The present study had certain limitations that should be considered while interpreting the findings. The sample size was limited to 30 participants, which is commonly seen in pre-experimental research

designs, and no formal sample size calculation was performed before the study; additionally, the alpha and beta error levels were not predetermined, which may have affected the statistical power and precision of the results. The study duration was limited to eight months, and knee joint range of motion was the primary outcome measure, which may not have fully captured functional improvements. Genu recurvatum was defined as knee extension greater than five degrees, and the age group of participants was restricted to 18–30 years, thereby limiting the generalizability of the findings to other populations. Furthermore, the absence of a control group restricts the ability to establish a cause-and-effect relationship. Despite these limitations, statistically and clinically significant improvements were observed. Future research should include a larger sample size with appropriate sample size calculations and predefined alpha and beta error levels, involve participants from different age groups, and incorporate longer follow-up periods. Additionally, adopting a multi-modal intervention approach that includes joint mobilization and a comprehensive exercise program emphasizing gluteus maximus strengthening may provide more robust and long-term outcomes.

The findings of the present study are consistent with previous research that reported a significant association between increased genu recurvatum angle and decreased gluteus maximus muscle strength. While earlier studies primarily established a correlation between gluteus maximus weakness and genu recurvatum, the present study extends this evidence by demonstrating that targeted strengthening of the gluteus maximus results in a measurable reduction in the genu recurvatum angle. This supports the biomechanical rationale that improving hip extensor strength positively influences knee joint alignment.

The findings of the present study demonstrated a significant improvement in genu recurvatum knee range of motion following gluteus maximus strengthening. On comparison of the mean values within the group, the pretest genu recurvatum knee ROM was 6.10 ± 0.803, which reduced to 5.20 ± 0.761 in the post-test assessment. This reduction in knee hyperextension was found to be highly statistically significant, with a t-value of 10.25 at $p \leq 0.001$, indicating a marked improvement following the intervention. The post-test values showed clear improvement when compared to pre-test measurements, thereby confirming the effectiveness of gluteus maximus strengthening in reducing genu recurvatum angle and leading to rejection of the null hypothesis. This improvement may be attributed to enhanced hip extensor strength and improved proximal stability, which reduced compensatory knee hyperextension during standing and functional activities. These results support the biomechanical concept that strengthening the gluteus maximus positively influences knee joint alignment and plays a crucial role in the conservative management of genu recurvatum.

Conclusion

The present pre-experimental study concludes that gluteus maximus strengthening is effective in reducing genu recurvatum angle among individuals aged 18–30 years. A statistically highly significant improvement was observed in knee range of motion following the intervention, as evidenced by the reduction in mean genu recurvatum angle from pre-test to post-test values ($p \leq 0.001$). The findings suggest that strengthening the gluteus maximus enhances proximal hip stability and improves lower limb alignment, thereby reducing compensatory knee hyperextension. Hence, gluteus maximus strengthening can be considered an effective conservative management approach for individuals with genu recurvatum.

Acknowledgement

The authors sincerely thank the management, faculty, and staff of Revathi Institute of Physiotherapy for their valuable support and guidance. We also extend our gratitude to all the participants for their cooperation and participation in this study.

Authors contribution

Pragadeeshwaran P: Conceptualization, Methodology, Participant recruitment, Data collection, Formal analysis, Manuscript drafting.

Dr. Nithya V: Supervision, Methodology validation, Critical revision of the manuscript, Final approval of the manuscript.

Dr. P. Bright Alwin Victor: Research guidance, Manuscript review, Administrative support, Final approval of the manuscript.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this study.

Data Availability

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

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