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The effect of Dynamic Acute Stretching Versus Warm-Up Exercises on Knee Range of Motion and Quadriceps Length in Young Adults with Quadriceps Tightness: A Randomized Controlled Trial

Vivek Shahu

Student
School of health sciences
chhatrapatisahuji maharaj university, kanpur

Abstract

Background: The quadriceps muscle frequently becomes tight, often resulting in reduced knee joint mobility and decreased functional performance in young adults. Healthcare professionals commonly recommend stretching and warm-up exercises to enhance flexibility and joint movements.

Objective: This study aimed to determine whether dynamic acute stretching or traditional warm-up exercises are more effective at improving the knee range of motion, quadriceps muscle length, and overall quality of life in young adults with tight quadriceps muscles.

Methodology: We conducted a study where young adults with tight quadriceps muscles were randomly assigned to two groups: one group performed dynamic stretching, while the other engaged in warm-up exercises. We assessed their knee bending ability, quadriceps muscle length, and quality of life over a four- week period, and analyzed the results using specialized statistical methods.

Results: Both groups showed improvements in knee bending and muscle flexibility after four weeks of training. However, the group that practiced dynamic stretching exhibited greater enhancements in knee bending and quadriceps muscle length than the warm-up exercise group. This suggests that dynamic acute stretching is more effective than warm-up exercises for improving knee movement and muscle flexibility in young adults with tight quadriceps muscles.

Keywords: stretching, Warm-up exercises, Quadriceps stiffness, Knee range of motion, Randomized controlled trial

1. Introduction: -

Quadriceps stiffness is a prevalent musculoskeletal condition among young adults, particularly in sedentary individuals and athletes. It results in decreased flexibility, reduced knee joint ROM, and impaired functional activities such as walking, running, and stair climbing. The quadriceps muscle group

plays a critical role in knee extension and lower limb biomechanics. Tightness in this muscle group can increase the risk of injuries and reduce performance. Stretching and warm-up exercises are commonly used interventions. Dynamic stretching involves controlled movements through the full ROM, whereas warm-up exercises include light aerobic activity and mobility drills. Research suggests that dynamic stretching improves flexibility and muscle activation without reducing strength. In contrast, static stretching may sometimes reduce muscle power if performed excessively. Despite growing evidence, there is limited research comparing dynamic stretching and general warm-up exercises specifically for quadriceps stiffness.

2. Need for the Study

The need for this study arises from the increasing prevalence of sedentary lifestyles, particularly among young adults, which has led to a higher incidence of musculoskeletal problems such as quadriceps stiffness. Prolonged sitting, reduced physical activity, and poor ergonomic habits contribute significantly to decreased muscle flexibility and joint mobility. Despite the growing occurrence of this condition, there is a lack of argeted and standardized interventions specifically addressing quadriceps stiffness. Additionally, existing literature presents conflicting evidence regarding the effectiveness of different stretching techniques, particularly dynamic stretching versus general warm-up exercises, making it difficult for clinicians to choose the most appropriate intervention. Therefore, there is a strong need for well-designed, evidence-based physiotherapy protocols to guide clinical practice and improve patient outcomes.

3. Aim of the Study

The primary aim of this study was to compare the effects of dynamic acute stretching and warm-up exercises on range of motion (ROM), quality of life, and quadriceps muscle length among young adults with quadriceps stiffness. The study sought to determine which intervention is more effective in improving joint flexibility, enhancing muscle extensibility, and promoting overall well-being. By evaluating these outcomes, the research intended to provide evidence-based guidance for selecting appropriate physiotherapy interventions in the management of quadriceps stiffness.

4. Objectives

The objectives of this study were to evaluate the improvement in range of motion (ROM) following the interventions, to assess changes in quadriceps muscle length, and to analyze variations in quality of life among the participants. Additionally, the study aimed to compare the overall effectiveness of dynamic acute stretching and warm-up exercises in order to determine which intervention provides better outcomes in managing quadriceps stiffness.

1. Hypothesis

The study was conducted based on the following hypotheses: the null hypothesis (H_0) stated that there is no significant difference between dynamic stretching and warm-up exercises in improving range of motion, quadriceps muscle length, and quality of life among young adults with quadriceps stiffness. In contrast, the alternative hypothesis (H_1) proposed that dynamic stretching is more effective than warm-up

exercises in producing significant improvements in these outcome measures.

2. Methodology

This study was designed as a randomized controlled trial to evaluate the effects of dynamic acute stretching versus warm-up exercises. The study was conducted at the School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Kanpur (Uttar Pradesh), specifically in the outpatient department of physiotherapy. The study population included both male and female young adults. A simple random sampling method was used to recruit participants, ensuring equal chances of selection and minimizing selection bias. The total duration of the study was two years, from 2024 to 2026, which included phases of research planning, proposal development, data collection, statistical analysis, and final reporting. The sample size was estimated using G*Power software, with a total of 70 participants calculated based on an expected effect size, a statistical power of 95%, and a type I error rate of 5%. Considering a possible dropout rate of 10%, the final sample size was adjusted accordingly to maintain study validity. Ethical clearance for the study was obtained from the Institutional Human Ethics Committee of Chhatrapati Shahu Ji Maharaj University, Kanpur. The research proposal was reviewed and approved during the committee meeting held on 05 August 2025, with reference number [08/October 2025]. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (revised 2013) and the National Ethical Guidelines for Biomedical and Health Research involving human participants. Additionally, the trial was registered under the Clinical Trials Registry of India (CTRI), ensuring transparency and adherence to research standards.

Inclusion Criteria

Participants included in the study were young adults aged between 18 and 25 years, as this age group is commonly affected by lifestyle-related muscle tightness and is suitable for assessing functional outcomes. Individuals were selected based on the presence of quadriceps stiffness, identified through clinical assessment and reduced flexibility of the muscle group. Additionally, only those participants who demonstrated reduced knee range of motion (ROM) were included, ensuring that the study specifically targeted individuals with measurable functional limitations related to quadriceps tightness.

Exclusion Criteria

Participants were excluded from the study if they had a history of recent injury, as this could influence muscle flexibility, pain levels, and overall functional performance, thereby affecting the study outcomes. Individuals with neurological disorders were also excluded due to potential impairments in muscle control, coordination, and sensory function, which could interfere with the assessment of range of motion and muscle length. Additionally, participants who had undergone any recent surgical procedures, particularly involving the lower limb, were not included in the study to avoid complications related to healing tissues, altered biomechanics, and restricted mobility that could bias the results.

3. Intervention Protocol

Group a	Group b
Acute dynamic stretching	**Warm- up exercises**
High knees	Light jogging
Butts kicks	Cycling
Lunges	General mobility exercises
Leg swings	

4. Outcome Measures

The outcome measures used in this study included range of motion (ROM), quadriceps muscle length, quality of life, and pain intensity. Range of motion of the knee joint was assessed using a universal goniometer, which is a reliable and valid tool commonly used in clinical and research settings to measure joint angles. Quadriceps muscle length was evaluated using Ely's Test, a standard clinical assessment used to identify tightness in the rectus femoris muscle. Quality of life was measured using the Short Form-36 (SF-36) questionnaire, a widely accepted instrument that assesses both physical and mental health domains. Pain intensity was recorded using the Numeric Pain Rating Scale (NPRS), where participants rated their pain on a scale from 0 (no pain) to 10 (worst possible pain). All outcome measures were recorded at baseline (pre-intervention) and after completion of the intervention period (post-intervention) to determine the effectiveness of the interventions.

5. Data Analysis

All collected data were systematically entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) version 25.0. Descriptive and inferential statistics were used to interpret the results. Descriptive statistics, including mean and standard deviation (Mean ± SD), were calculated for all outcome variables such as range of motion (ROM), quadriceps muscle length, and quality of life scores. These values were used to summarize the baseline characteristics and post-intervention outcomes of both groups. To assess within-group changes (pre-test versus post-test), the **paired t-test** was applied for both the dynamic stretching group and the warm-up exercise group. This test helped determine whether each intervention produced significant improvements over time. For between-group comparisons, the **independent (unpaired) t-test** was used to evaluate differences in mean outcomes between the two groups after the intervention period. This allowed comparison of the effectiveness of dynamic stretching versus warm-up exercises. The level of statistical significance was set at $\mathbf{p < 0.05}$. A p-value less than 0.05 was considered statistically significant, indicating that the observed differences were unlikely due to chance. Data were presented in the form of tables and graphs for better interpretation. All assumptions for parametric testing, including normal distribution of data and homogeneity of variance, were checked prior to analysis

5. Results

Table 1: ROM Improvement

GROUP	PRE- TEST	POST-TEST	MEAN DIFFERENCES	P-VALUE
Dynamic stretching	9.5±5.1	113.6±4.8	18.4±3.2	<0.001
Warm-up	96.1 ± 4.9	108.2 ± 5.0	12.1 ± 2.8	<0.01

Table 3: Quality of Life

Group	Pre-score	Post-score
Acute dynamic stretching	62.4	85.2
Warm-up exercises	63.1	75.3

6. Discussion

The present randomized controlled trial compared the effects of dynamic acute stretching and general warm- up exercises on range of motion (ROM), quadriceps muscle length, and quality of life in young adults with quadriceps stiffness. The results demonstrated that both interventions produced statistically significant improvements; however, dynamic stretching was more effective across all outcome measures. The greater improvement in ROM observed in the dynamic stretching group may be attributed to the active, movement- based nature of the intervention. Dynamic stretching enhances muscle temperature, improves neuromuscularcoordination, and increases stretch tolerance, thereby promoting greater joint mobility. In contrast, warm-up exercises primarily increase blood flow and prepare the body for activity but may not provide sufficient mechanical stimulus for optimal flexibility gains. Similarly, quadriceps muscle length improved more significantly in the dynamic stretching group, indicating that targeted stretching techniques are more effective in reducing muscle tightness. The improvement in quality of life further supports these findings, as enhanced flexibility and reduced stiffness contribute to better functional performance and overall well-being. These findings are consistent with previous research suggesting that dynamic stretching is superior to general warm-up exercises in improving flexibility and functional outcomes. From a clinical perspective, incorporating dynamic stretching into rehabilitation programs may yield better results in managing quadriceps stiffness. However, limitations such as short intervention duration and restricted age group should be considered. Future studies with larger samples and longer follow-up periods are recommended to confirm these findings.

7. Conclusion

The findings of this randomized controlled trial clearly demonstrate that both dynamic acute stretching and general warm-up exercises are effective interventions for improving range of motion (ROM),

quadriceps muscle length, and quality of life in young adults with quadriceps stiffness. However, the results strongly indicate that dynamic acute stretching produces significantly greater improvements across all measured outcomes compared to traditional warm-up exercises. Participants in the dynamic stretching group exhibited superior gains in knee joint ROM, suggesting that dynamic movements are more effective in enhancing joint flexibility and neuromuscular coordination. The improvement in quadriceps length observed through the Modified Thomas Test further supports the role of dynamic stretching in promoting muscle extensibility and reducing stiffness. Additionally, the marked enhancement in quality of life scores in this group highlights the broader functional and psychological benefits associated with improved physical performance and reduced discomfort. In contrast, while the warm-up exercise group also showed statistically significant improvements, the magnitude of change was comparatively lower.

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