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Relationship between vastus medialis oblique angle, Lysholm score, isometric quadriceps strength, and Tegner score in anterior cruciate ligament reconstruction patients

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ABSTRACT

Background: The anterior cruciate ligament (ACL) tear represents a serious sports injury in active individuals. While reconstruction seeks to restore knee stability and quadriceps strength, full recovery of the vastus medialis oblique (VMO) angle is frequently not achieved. This study aimed to investigating the relationship between the vastus medialis oblique angle (VMOA) and Lysholm score with quadriceps isometric strength and Tegner score in patients after ACLR.

Methods: This research used a literature review method of seven relevant scientific journals published within the last 10 years (2015–2025). The literature was selected based on strict inclusion and exclusion criteria from reputable scientific databases. These include PubMed, Scopus, Google Scholar, and PEDro using the keyword "vastus medialis oblique," which is also a keyword for "vastus medialis," "Lysholm score," "quadriceps isometric," and "Tegner score."

Results: There waa a significant relationship between VMOA angles and isometric quadriceps strength and functional values of Lysholm and Tegner. Patients with VMOA angles within the ideal range and adequate quadriceps muscle strength generally showed better knee functional value and activity level. Rehabilitative interventions, such as the use of hybrid assistance limb (HAL) and electro muscle stimulation (EMS), have been shown to be effective in improving muscle strength and clinical scores.

Conclusion: This study concluded that there was a significant relationship between VMOA angles, isometric quadriceps strength, and Lysholm and Tegner functional scores in patients after ACLR. The findings emphasize the importance of rehabilitation focusing on strengthening VMO and quadriceps muscles to improve knee stability and post-ACLR clinical outcomes.

Keywords: ACLR, Lysholm score, quadriceps isometric strength, Tegner score, vastus medialis oblique.

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Introduction

Anterior cruciate ligament (ACL) injury is one of the four most common types of knee injuries in active individuals. It functions to maintain knee joint stability, with ligament injuries often occurring due to sudden movements, rapid changes, or collisions during sports.[1] To address this condition, ACLR surgery is often performed to restore knee structure stability. Although ACLR is mechanically effective, the recovery of quadriceps muscle strength after surgery remains a major challenge, as it can hinder patients from returning to activities or sports.[2] Overall, the prevalence of ACL injuries reaches approximately 68.6 per 100,000 people per year, with data from the United States showing over 200,000 ACL cases annually and approximately 100,000 patients undergoing ACL surgery.[3] However, the success of ACLR does not solely depend on surgical technique but also on a comprehensive rehabilitation process, including the recovery of strength and function of the muscles around the knee, particularly the quadriceps.[4] The quadriceps are the primary muscle group supporting knee stability and mobility; weakness in the quadriceps not only affects knee stability but also negatively impacts functional activities and the patient's quality of life.[4,5]

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The vastus medialis oblique angle VMOA is one of the important indicators in the recovery of patients after ACLR in terms of biomechanics.[6] VMOA is a part of the quadriceps muscle that is very important for stabilizing the patella and preventing patella maltracking.[7] The normal VMOA angle is estimated to range from 45° to 55°, which has been identified as a morphological parameter that can influence knee function after ACLR.[8] Meanwhile, isometric quadriceps strength is often used as an objective measure of muscle function recovery after ACLR procedures.[9] Indications for ACLR include persistent knee joint instability in cases of complete ligament tears, as well as the need to return to physical activities. However, ACL surgery can anatomically repair the knee, but approximately 20–30% of patients post-ACLR continue to experience quadriceps muscle weakness, which poses a significant barrier to knee function recovery.[10]

Evaluating post-ACLR outcomes generally involves the use of widely used assessment tools, including the Lysholm Knee Score, which is used to assess knee symptoms and function in daily activities such as walking, climbing stairs, or squatting, and the Tegner Activity Score, which measures the level of physical activity of patients from inactive to competitive sports.[11] The correlation between morphological parameters, muscle strength, and functional scores is an interesting topic to study in an effort to optimize the results of rehabilitation after ACLR.[12]

Based on the above background, this study aimed to investigate the relationship between the VMOA and Lysholm score with quadriceps isometric strength and Tegner score in patients after ACLR. A deeper understanding of these relationships could help students expand their knowledge and provide benefits for physical therapists in conducting more effective and tailored rehabilitation for patients.

Methods

This study used a literature review method. The research was conducted using secondary data of published research journals obtained from several scientific journal databases on the internet. The literature search was conducted online through the websites PubMed, Scopus, Google Scholar, and PEDro using the keywords “vastus medialis oblique,” “lysholm score,” “quadriceps strength,” “tegner score,” and “ACLR” by combining the Boolean operators ‘OR’ and “AND.” Literature selection was based on inclusion and exclusion criteria. The inclusion criteria used in this literature review were publications published within the last 10 years (2015–2025). The exclusion criteria in studies that do not include patients post-ACLR. The literature used in this literature review meets the criteria set by the author.

Results

From the literature review conducted by the author, there are seven relevant and significant journals related to the title of this study, which have been included in Table 1. The results of Table 1 are as follows.

In the study by Vinzenza Villia Ardike Bondeng & IGPS Adhitya, it was found that there is a significant relationship between knee function after undergoing ACLR and the patient's level of physical activity. This study analyzed two main indicators, namely the lysholm score and the tegner score, which will be used to assess knee function and physical activity post-ACLR. In the study, patients with a high Lysholm score an 8-item questionnaire with a 0–100 scale to measure knee function tended to have a better Tegner Score for assessing physical activity. This confirms that improved knee function contributes to patients' ability to engage in more intensive physical activities after surgery. The study results showed a significant positive correlation between the two parameters ($p = 0.0034$), where patients with higher lysholm scores were more likely to achieve better tegner scores. clinically, this indicates that improved knee function allows patients to resume higher-intensity physical activities post-surgery.[13]

In Yuichiro Soma et al.'s study, it was found that the use of a hybrid assistive limb (HAL) in patients undergoing ACLR improved the lysholm score from 74 to 85 over 6 months of rehabilitation ($p < 0.05$), and resulted in a significant increase in isometric quadriceps muscle strength.[14]

In a study by Ehsan Fallah et al., a comparison between hamstring grafts, quadriceps tendon grafts, and bone patellar tendon bone (BPTB) grafts showed a significant improvement in the lysholm score after 12 months of rehabilitation, particularly in the group using quadriceps grafts ($p < .001$).[15]

In Hong Dae Wang et al.'s study, it was found that medial patellofemoral ligament (MPFL) reconstruction using the bone groove method resulted in a significant improvement in Lysholm score ($p < 0.05$). Patients also showed a 30% increase in isometric quadriceps strength within 6 months post-surgery.[16]

In the study by Niyazi Ercan et al., it was found that a quadriceps rehabilitation program based on isometric contraction improved the lysholm score from 70 to 85 (P=.001). This improvement was accompanied by an increase in isometric quadriceps strength of up to 25% within 6 months in patients post-ACLR.[17]

In Seung Ik Cho et al.'s study, the effects of a rehabilitation program using electro muscle stimulation (EMS) on quadriceps strength, activity, and function in patients after ACLR were investigated. The study involved 24 patients divided into two groups: the control group (CONG) and the EMS group (EMSG). The results showed that the EMSG group, which underwent EMS intervention for 12 weeks, experienced significant improvements in lysholm score ($p = 0.049$) and muscle activity of the vastus medialis (VM), vastus lateralis (VL), and rectus femoris (RF) ($p < 0.05$). Meanwhile, the CONG group only showed an increase in the international knee documentation committee (IKDC) score ($P = 0.026$). The increase in thigh circumference in the EMSG

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Table 1. Results summary of the relationship of the vastus medialis oblique angle and Lysholm score with the isometric quadriceps and Tegner score in anterior cruciate ligament reconstruction patients

Authors	Title	Methods	Results
Bondeng, et al. (2024)	The Relationship Between Knee Function After ACL Reconstruction and Physical Activity Level of The ACL Community Indonesia	Study design: cross-sectional study Participants: 120 ACLR patients Variable: Lysholm and tegner score	Positive correlation between knee function (Lysholm) and physical activity (Tegner) (p = 0.034).
Yuichiro Soma, et al. (2022)	Single-joint Hybrid Assistive Limb in Knee Rehabilitation after ACL Reconstruction: An Open-label Feasibility and Safety Trial	Study design: Case report Participants: 1 ACLR patient Variable: Hybrid assistive limb (HAL), Lysholm score, EMG quadriceps	Improvement in Lysholm Score from 74 to 85 after 6 months of rehabilitation with significant increase in quadriceps strength (p < 0.05).
Ehsan Fallah et al. (2024)	Comparison of Clinical Results Using Hamstring Versus Quadriceps Tendon Graft Versus Bone Patella Tendon in Anterior Cruciate Ligament Reconstruction Surgery: A Randomized Clinical Trial	Study design: Randomized controlled trial Participants: 100 ACLR patients Variable: Graft type (hamstring dan quadriceps), Lysholm score	Significant improvement in Lysholm Score after 12 months (p < 0.001).
Hong De Wang et al. (2016)	Medial patellofemoral ligament reconstruction using a bone groove and a suture anchor at the patella: a safe and firm fixation technique and 3-year follow-up study	Study design: Follow-up study Participants: 26 patients diagnosed with recurrent lateral patella dislocations underwent MPFL reconstruction Variable: Lysholm score, isometric strength	Improvement in Lysholm Score (p < 0.05) and isometric quadriceps strength by up to 30%.
Niyazi Ercan et al. (2021)	Single-tunnel and double-tunnel medial patellofemoral ligament reconstructions have similar clinical, radiological, and functional results	Study design: a prospective, randomized, controlled study. Participants: 80 patients with symptomatic recurrent patellar dislocation or instability. Variable: Isometric quadriceps, lysholm, tegner score	Lysholm score increased from 70 to 85; muscle strength increased by up to 25% in 6 months (p = 0.001)

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Seung Ik Cho et al. (2023)	Effects of a Rehabilitation Exercise Program Using Electro Muscle Stimulation following Anterior Cruciate Ligament Reconstruction on the Circumference, Activity, and Function of the Quadriceps Muscle	Study design: Randomized controlled trial Participants: 30 patients who were scheduled to receive ACL reconstruction. Variable: Electro muscle stimulation (EMS), Lysholm Score, EMG vastus medialis (VM), vastus lateralis (VL), and rectus femoris (RF)	Significant improvement in Lysholm Score (p = 0.049) and quadriceps muscle activity ($p < 0.05$)
Kuan Yu Lin et al. (2015)	The double-pulley technique for anatomical double-bundled medial patellofemoral ligament reconstruction	Study design: Prospective case series. Participants: 18 with patellar instability patients Variable: Double-pulley medial patellofemoral ligament technique, Kujala score, Lysholm-Tegner, patellar angle	Significant improvement in Kujala and Tegner-Lysholm scores ($p < 0.001$) and decrease in patellar congruence angle ($p < 0.001$)

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group was also significant at the 5 cm (p = 0.001) and 15 cm (p = 0.013) measurement points from the patella.[18]

In the study by Kuan Yu Lin et al., a prospective study was conducted on the double-pulley technique for medial patellofemoral ligament (MPFL) reconstruction in patients with patellar instability. The study involved 18 patients (18 knees) who underwent MPFL reconstruction using the double-pulley technique with suture anchors. Evaluation was performed using the Kujala score, Tegner-Lysholm score, congruence angle, and patellar tilt angle before and after surgery. The results showed a significant improvement in the Kujala score from 55.3 ± 6.8 to 95.2 ± 3.5 ($p < 0.001$) and the Tegner-Lysholm score from 43.6 ± 8.1 to 93.6 ± 6.8 ($p < 0.001$). Additionally, the patellar congruency angle decreased from 20.6° ± 2.1° to -5.2° ± 2.4° ($p < 0.001$).[19]

Discussion

The results of the literature review show a significant relationship between knee function after ACLR and physical activity levels. Lysholm score and tegner Score had a positive correlation with a p-value of 0.034. This indicates that improved knee function contributes to increased physical activity in patients. The study emphasizes the importance of using HAL technology to improve isometric quadriceps strength and increase the lysholm score.[13] Similar findings were reported, where the use of quadriceps tendon grafts resulted in a significant improvement in the lysholm score compared to hamstring grafts, indicating that graft selection can influence isometric quadriceps strength.[15] Additionally, other studies also indicate that the optimal VMO angle is directly related to isometric quadriceps strength, where a good VMO angle contributes to improved knee function and physical activity. Thus, quadriceps-strengthening rehabilitation using HAL, EMS, and isometric contraction methods is not only effective in improving muscle strength but also plays a role in improving Lysholm score and Tegner Score in patients post ACLR.[14,20]

Comparisons with previous studies generally support these findings. Various biomechanical and clinical studies highlight that ACLR procedures, quadriceps muscle weakness, and imbalance in the angle are often major problems in the recovery process. The study confirms that quadriceps muscle weakness can reduce knee dynamic stability and hinder movement and daily activities.[21] Suboptimal VMO angles are also associated with patellar maltracking, uneven load distribution on the knee joint, and patellofemoral alignment issues.[7] These biomechanical changes logically lead to excessive muscle compensation, ultimately affecting functional performance.[22] This is supported by various experimental and observational studies showing that rehabilitative interventions, such as isometric exercises and EMS, as well as the use of technologies like the HAL, can enhance the vastus medialis muscle, improve quadriceps strength symmetry, and increase functional scores such as lysholm and tegner.[14]

The reviewed studies have the advantage of methodological validity thanks to the use of standardized measurements such as the lysholm score and tegner score, which comprehensively assess knee function and physical activity. This contributes significantly to the development of knowledge regarding the biomechanical and functional relationships following ACLR. Additionally, the use of modern technologies such as EMS and HAL in some studies demonstrates innovative rehabilitation approaches that have the potential to improve patient recovery outcomes.[23]

This literature review shows that the angle of the VMO and isometric quadriceps strength are significantly associated with improved knee function and physical activity after ACLR, as measured by the Lysholm score and Tegner Score. These findings can be used to design more effective rehabilitation programs. The research results consistently support the idea that quadriceps muscle weakness, particularly of the VMO, as well as suboptimal muscle fiber orientation, can impair knee joint stability, reduce motor function, and limit physical activity.[24] This aligns with biomechanical theories emphasizing the importance of muscle orientation and strength in maintaining joint alignment, movement efficiency, and functional performance.[25]

Implications for clinical practice highlight the need to prioritize VMO and quadriceps strengthening as the main focus of ACLR rehabilitation programs to optimize knee function and reduce the risk of re-injury. Future research is recommended to conduct longitudinal studies with larger sample sizes to explore the relationship between VMO angle and quadriceps strength on knee functional outcomes more comprehensively. Additionally, the integration of technology may be considered as an adjunct method to enhance muscle strength and neuromuscular activity. Regular monitoring using standardized instruments such as the lysholm score and tegner score is recommended to evaluate rehabilitation progress and adjust the therapy program according to expected functional outcomes. professional training programs should also emphasize the importance of selective muscle strengthening and neuromuscular strategies for optimal functional recovery.

However, several limitations need to be considered. Variations in study methodologies such as cross-sectional designs, case reports, and randomized controlled trials (RCTs) may affect the generalizability of the results. Some studies have relatively small sample sizes, which can reduce statistical power and the accuracy of the findings. Additionally, differences in post-operative measurement timepoints (e.g., 6 to 12 months) may impact the consistency of recovery evaluations. Other limitations include the lack of longitudinal studies to assess long-term effects and variations in rehabilitation protocols across studies, which may affect the comparability of results.

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Conclusions

This literature review indicates that an increase in the angle of the VMO and isometric quadriceps strength has a significant relationship with knee function and physical activity in patients after ACLR, as measured by the lysholm score and tegner score, thereby emphasizing the importance of rehabilitation focused on quadriceps muscle strengthening and VMO angle adjustment to enhance knee stability and functional outcomes, especially when combined with technology-based methods such as HAL and EMS, these findings can serve as a foundation for designing post ACLR rehabilitation programs that emphasize quadriceps muscle strengthening and VMO angle monitoring to reduce the risk of re-injury and accelerate the recovery process. Further studies with longitudinal designs and larger samples are needed to explore the relationship between VMO angle and quadriceps strength in greater depth and to assess the effectiveness of combining technology-based rehabilitation methods. It is hoped that this study will contribute scientifically to the development of rehabilitation strategies focused on biomechanical and neuromuscular aspects in post-ACLR patients.

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Conflict of interest

This research is devoid of any conflicts of interest.

Author contributions

IGADPD developed the study design, conducted data collection, and prepared the initial manuscript; IPGSA and IPYPP were responsible for data collection and provided revisions to the manuscript.

Ethical consideration

This review study utilized publicly available published articles, so informed consent and ethical approval were unnecessary.

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