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The relationship between the cross-sectional area of the vastus medialis oblique muscle and the anterior cruciate ligament return to sport index with the lateral step down test and the knee injury and osteoarthritis outcome score questionnaire in post–anterior cruciate ligament reconstruction patients

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ABSTRACT

Background: Anterior cruciate ligament (ACL) reconstruction is a surgical procedure performed to repair a torn ACL. This procedure may lead to atrophy of the cross-sectional area (CSA) of the vastus medialis oblique (VMO), which could potentially impact the patient's psychological condition. This study aimed to examine the relationship between the cross-sectional area of the VMO and ACL-RSI with the lateral step down test and KOOS questionnaire in post-ACL reconstruction patients.

Methods: This study is a literature review that analyzes previous research articles as secondary data sources. The literature search was conducted using the PEO framework: Patient (P) = post-ACL reconstruction patients, exposure (E) = cross-sectional area of the vastus medialis oblique, outcome (O) = lateral step down test and KOOS. The keywords used were: "cross-sectional area of vastus medialis oblique," "anterior cruciate ligament return to sport injury," "lateral step down test," "knee injury and osteoarthritis outcome score questionnaire," and "anterior cruciate ligament reconstruction," selected based on their relevance to the study topic.

Results: Patients who had undergone ACL reconstruction showed no significant relationship between VMO CSA and KOOS scores ($p > 0.05$). However, there was a significant relationship between ACL-RSI scores and KOOS subscales of quality of life and sports and recreation ($p < 0.05$). No studies were found that directly examined the relationship between the lateral step down and either VMO CSA or ACL-RSI.

Conclusion: There was a significant relationship between psychological readiness (ACL-RSI) and perceived knee function (KOOS). However, no significant association was found between muscle morphology (VMO CSA) and KOOS. Furthermore, no direct evidence currently links either VMO CSA or ACL-RSI to lateral step down test performance in patients following ACL reconstruction.

Keywords: ACL-RSI, anterior cruciate ligament reconstruction, knee injury, lateral step-down test, osteoarthritis outcome score, vastus medialis oblique cross-sectional area.

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Introduction

Knee injury is a commonmusculoskeletal complaintafter low back pain, in Indonesia. The prevalence of knee injury was 48 per 1000 patients, of which 9% were anterior cruciate ligament (ACL) injuries.[1] ACL injury is one of the most common ligament injuries, particularly among athletes and physically active individuals.[2,3] It can result in impaired lower limb function, characterized by joint instability, knee pain, limited range of motion, quadriceps weakness, and difficulty performing functional movements.[4,5] ACL reconstruction (ACLR) is a surgical intervention involving tendon grafting, which may use either an allograft (donor tissue) or an autograft (commonly the patient's own ipsilateral patellar or medial hamstring tendon) that performed surgical procedure to overcome the injury.[6,7]

is a The primary goal of ACLR is to restore knee stability and biomechanical function post-injury.[8] However,

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ACLR patients often experience pain, swelling, and reduced range of motion after surgery, potentially leading to functional limitations and reduced quality of life.[9] Insufficient rehabilitation after ACLR also contributes to muscle strength decline and a reduction in muscle cross-sectional area around the knee, particularly affecting the vastus medialis oblique (VMO) muscle.[10]

The vastus medialis oblique plays a crucial role in knee stability. The cross-sectional area (CSA) of the VMO refers to the anatomical area formed by this muscle, which is part of the quadriceps group. It functions to assist in knee extension and stabilizing the knee joint, especially during gait or running. VMO CSA can be measured using ultrasound imaging.10 ACLR often results in long-term atrophy and weakness of the quadriceps muscle group, which may also affect the psychological condition of the patient.[11]

Psychological factors are closely associated with physical capacity following ACLR and may influence an athlete's readiness to return to sport.[12,13] These psychological aspects can be evaluated using the ACL-return to sport after injury (ACL-RSI) scale, which specifically measures the patient's psychological readiness to return to sport after ACL reconstruction.[14,15] Developed in 2008, the ACL-RSI includes 12 items assessing confidence and fear related to performance, reinjury, and returning to sports.14 It is important to consider variables such as age, sex, and the time elapsed between injury and surgery, which may influence ACL-RSI scores. Psychological readiness and functional knee ability significantly affect physical activity performance post-ACLR.[15,16] Functional knee ability can be assessed through the lateral step down test, a clinical evaluation tool for analyzing movement quality in individuals with knee dysfunction. This test is used to identify abnormal movement patterns of the hip and knee.17 Visual assessment during the lateral step-down test has been correlated with objective motion capture systems such as 2D video analysis.

The knee injury and osteoarthritis outcome score (KOOS) is a validated instrument used to assess knee function post-ACLR. KOOS is a patient-reported outcome measure that evaluates health status, symptoms, and functional ability of the knee. It consists of 42 items across five subscales: pain, symptoms, activities of daily living (ADL), sport and recreation function, and quality of life (QoL). The maximum score is 100, indicating no knee problems, while the minimum is 0, indicating severe knee issues.

Therefore, the objective of this literature review was to examine the relationship between the cross-sectional area of the VMO and ACL-RSI with the lateral step-down test and KOOS questionnaire in patients following ACL reconstruction surgery.

Methods

This study used the literature review method to examine research articles as secondary data sources. The literature search was conducted using the PEO framework, patient (P) = post-ACL reconstruction patients, exposure (E) = cross-sectional area of the vastus medialis oblique, outcome (O) = lateral step down test and KOOS. The keywords used were: "cross-sectional area of vastus medialis oblique," "anterior cruciate ligament return to sport injury," "lateral step down test," "knee injury and osteoarthritis outcome score questionnaire," and "anterior cruciate ligament reconstruction" all selected based on relevance to the research topic and presence in article content. Inclusion criteria included literature discussing the relationship between the VMO cross-sectional area and ACL-RSI with the lateral step down test and KOOS, and written in English. Exclusion criteria included articles published more than 10 years prior to this review. Literature was searched online from databases such as PubMed, google scholar, and the journal of sport rehabilitation. From this search, 20 articles were found relevant based on the selected keywords. After applying the inclusion and exclusion criteria, a total of 5 articles met the eligibility criteria, while 15 articles were excluded.

Results

Based on tabel 1. The review of five selected studies, a significant correlation was generally found between ACL-RSI and KOOS, particularly in the KOOS subscales of QoL and Pain. The study by Kim et al. (2022) reported that the risk appraisal component of the ACL-RSI was significantly positively correlated with KOOS-QoL ($r = 0.75$, $p < 0.05$), indicating that psychological readiness plays a role in perceived quality of life following ACL reconstruction.[18]

The literature review by Bondeng et al. (2023) also supported the relationship between ACL-RSI and KOOS Pain, although it did not explicitly report a p-value.[15] Similarly, Betsch et al. (2021) found a significant association between KOOS scores and ACL-RSI scores ($p < 0.001$), reinforcing the connection between psychological status and perceived knee function.[19]

In contrast, the relationship between VMO CSA and KOOS was explicitly analyzed only in the study by Hunnicutt et al. (2020), which reported no significant correlation between VMO CSA and KOOS Sport/Rec ($rs = 0.161$, $p > 0.05$), suggesting that muscle morphology does not always reflect a patient's functional perception.[20]

The study by Mostaed et al. (2018) examined biomechanical performance using the LSDT, but did not directly relate it to either ACL-RSI or KOOS, nor did it evaluate VMO CSA.[17]

Discussion

Previous studies reported no significant correlation between the cross-sectional area (CSA) of the vastus medialis oblique (VMO) muscle and the KOOS sport and recreation subscale ($rs = 0.161$, $p > 0.05$), indicating that structural muscle size may not correspond with patients'

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Table 1. Analysis of the relationship between cross sectional area vastus medialis oblique and ACL-RSI with lateral step down test and KOOS questionnaire in post-ACL reconstruction patients

Author (Year)	Study Design	Population	Sample Size	Methods	Main Results
Mostaed et al. (2018)[17]	Cross-sectional	Individuals aged 18–40 years with a history of ACL reconstruction (≥1 year)	20	lateral step down test	Lateral step down test was analyzed in detail using kinematic evaluation; however, CSA of VMO and ACL-RSI were not included as variables.
Bondeng et al. (2023)[15]	Literature review	Post-ACLR athletes	622	KOOS and ACL-RSI	KOOS scale was significantly associated with higher ACL-RSI scores. A relationship was found between KOOS pain and psychological readiness (ACL-RSI), although no statistical test or p-value was reported.
Kim et al. (2022)[18]	Prospective	Patients with ACL reconstruction at least 24 months post-surgery	85	ACL-RSI and KOOS	ACL-RSI was significantly correlated with KOOS-QoL ($r = 0.75$, $p < 0.05$), indicating psychological readiness influences QoL after ACL reconstruction.
Betsch et al. (2021)[19]	Retrospective	Patients with unilateral ACL tear in an academic center (mean age: 28.2 years; 63% male)	113	KOOS and ACL-RSI	KOOS scores were significantly associated with ACL-RSI scores ($p < 0.001$).
Hunnicutt et al. (2020)[20]	Cross-sectional	Patients 6–23 months post-ACLR	30	CSA of VMO and KOOS	No significant correlation between CSA of VMO and KOOS ($rs = 0.161$, $p > 0.05$).

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; ACL-RSI, anterior cruciate ligament return to sport injury; CSA, cross-sectional area; KOOS, knee injury and osteoarthritis outcome score; QoL, quality of life VMO, vastus medialis oblique.

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perceived functional outcomes.[20] Conversely, several studies demonstrated a significant relationship between ACL-RSI and KOOS. For example, a strong correlation was found between the risk appraisal component of ACL-RSI and KOOS-QoL ($r = 0.75$, $p < 0.05$).[18] Similarly, other findings showed a statistically significant association between ACL-RSI and KOOS scores ($p < 0.001$), emphasizing the importance of psychological readiness in determining perceived QoL post-ACLR.[19] Meanwhile, another study explicitly assessed LSDT performance using kinematic analysis, but it did not evaluate its correlation with KOOS or ACL-RSI.[17] Therefore, no conclusion can be drawn regarding the relationship between the lateral step down test and either subjective perception or psychological readiness

The absence of a correlation between VMO CSA and KOOS can be explained by the fact that muscle size does not necessarily reflect the quality of contraction or the effectiveness of neuromuscular activation.[21] After ACL reconstruction, even when muscle mass is relatively preserved, deficits in motor control and arthrogenic muscle inhibition frequently occur as a result of pain, joint effusion, or inflammation.[22] These factors interfere with voluntary quadriceps activation, leading to activation failure despite adequate muscle volume.[23] Experimental studies have demonstrated that intra-articular effusion and pain can reduce quadriceps torque and electromyographic activity, supporting this mechanism.[24] Consequently, muscle structure alone (such as CSA) may not accurately represent the functional performance perceived by patients, as reflected in KOOS scores.[20]

Therefore, structural measurements such as CSA may not sufficiently represent patients' functional capacity. In contrast, the consistent relationship between ACL-RSI and KOOS indicates that psychological readiness plays a crucial role in functional recovery.[25] Patients with greater confidence in knee stability and reduced fear of reinjury tend to report higher KOOS scores, reinforcing the biopsychosocial nature of post-ACLR recovery.[26] Recent studies have also reported that ACL-RSI scores are strongly correlated with the KOOS pain and QoL subscales even up to two years postoperatively, suggesting that psychological factors exert long-term influence on perceived quality of life.[27] Similar findings have been observed in the Indonesian population, where psychological factors such as kinesiophobia and readiness were associated with functional outcomes and recovery time after ACL reconstruction.[28]

Overall, the reviewed studies suggest that psychological factors such as ACL-RSI are more consistently and significantly associated with KOOS than morphological indicators like VMO CSA. Moreover, the use of the lateral step down test as a statistically evaluated measure in relation to ACL-RSI or KOOS remains rare in current literature.

Based on the review of several studies evaluating the relationships among VMO, CSA, ACL-RSI, KOOS, and functional performance tests like the lateral step down test, there is stronger and more consistent evidence supporting the association between ACL-RSI and KOOS particularly the subscales of quality of life and sport and recreation. Psychological readiness following ACL reconstruction plays a crucial role in shaping patients' perceptions of knee function.

In contrast, the relationship between VMO CSA and KOOS remains statistically insignificant, and the limited number of studies prevents definitive conclusions. Additionally, although the LSDT is commonly used in biomechanical evaluations after ACL reconstruction, it has rarely been directly examined in relation to morphological or psychological variables such as CSA or ACL-RSI.

However, this review also identified several limitations that should be taken into account. First, the limited number of studies that directly evaluated the relationship between CSA of the VMO and ACL-RSI with the lateral step-down test. In fact, most studies involving the lateral step-down test did not statistically associate it with either psychological or morphological variables. Second, only one study explicitly measured the CSA of the VMO, resulting in weak evidence regarding that variable. Some studies also had methodological limitations, such as small sample sizes and highly variable postoperative time frames among participants, which may have influenced the results. Furthermore, not all studies reported complete statistical values (such as p-values or correlations), which hindered further quantitative analysis.

Conclusions

Thus, it can be concluded that there was a limited literature regarding the relationship between quadriceps muscle morphology, psychological condition, and functional components in ACLR patients within a single research framework. Future research is strongly needed to comprehensively evaluate the interplay between muscle morphology, psychological readiness, and functional performance in order to support optimal recovery and return-to-sport decisions following ACL reconstruction.

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Conflict of interest

The authors declare that there are no potential conflicts of interest, financial or otherwise, that could be construed as influencing the research, the preparation of the manuscript, or the publication and dissemination of this manuscript. All authors affirm that their participation in this study and the preparation of this manuscript were conducted with the highest scientific integrity and without external pressures or personal interests that could

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compromise the objectivity or validity of the reported findings.

Author contributions

PPPIP developed the study design, conducted data collection, and prepared the initial manuscript; IMNW was 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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