

Kinesiophobia, Not Squat Loading Asymmetry, Correlates with Poor Patient-Reported Outcomes Following ACL Reconstruction

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Introduction: Bilateral squatting exercises are utilized during early rehabilitation following anterior cruciate ligament reconstruction (ACLR) to incrementally load the knee joint. When performed correctly, these exercises restore strength and functional movement patterns facilitating a progression toward higher-demand single-limb tasks. However, individuals may employ compensatory strategies while squatting that reduce the demand on their involved limb. Movement compensations may be due to physical factors such as quadriceps dysfunction or pain but may also be due to psychological factors such as kinesiophobia – excessive fear of physical activity resulting from the ACL injury. Evaluating limb-loading symmetry or offloading of the ACLR involved limb as a movement compensation, may allow for the early identification of movement patterns that result in increased risk of reinjury to the ipsilateral/contralateral ACL or poor patient-reported outcome measures (PROMs). Moreover, understanding the relationship between kinesiophobia and perceived knee function, and limb-loading symmetry during bilateral squat exercise over the course of the rehabilitation process may provide evidence for targeted integrated physical and psychological intervention to maximize recovery from ACLR. Therefore, the purpose of this study is to examine the relationship between limb-loading asymmetry during bilateral squat exercise and patient-reported kinesiophobia and perceived knee function early and late post-ACLR. We hypothesized that higher levels of kinesiophobia would be associated with greater limb-loading asymmetry in bilateral squat exercise early in rehabilitation, and that both factors would be negatively associated with PROMs.

Methods: This study is a secondary analysis of an IRB approved point-of care research study in patients with ACLR. Participants completed musculoskeletal assessments, including bilateral squat testing at multiple timepoints following ACLR and completed patient surveys. PROMs included the Tampa Scale for Kinesiophobia-11 (TSK-11), International Knee Documentation Committee score (IKDC), ACL-Return to Sport after Injury score (ACL-RSI), and five subscales of the Knee Injury and Osteoarthritis Outcome Score (KOOS): pain, function in daily living (ADL), symptoms, sports and recreational activities (Sport), and quality of life (QOL). Thirty-nine individuals (Age at surgery: 27.8±11.1 years, 49% female, 53.8% BTB autograft) were included in the study. Participants were included if they had one early (4 or 6 months) and one late (8, 10, or 12 months) timepoint that included both bilateral squat and TSK-11 outcomes. For the bilateral squatting task, participants were instructed perform 3 sets of 3 squats to the beat of a metronome (45 bpm), timing the top and bottom of the squatting motion at each beat, and reaching 90° of knee flexion with each repetition. Limb loading during the squatting task was measured using an instrumented pressure mat and represented as the average percent load distribution per limb. Correlation analyses were performed between TSK-11 scores and squat asymmetry measures and PROMs at early and late timepoints, and a mixed model analysis was employed to better understand the overall relationship between kinesiophobia, limb-loading symmetry, and PROMs throughout the full recovery timeline.

Results: Higher kinesiophobia was significantly associated with worse perceived knee function particularly during early rehabilitation. At early timepoints, greater TSK-11 scores (higher kinesiophobia) were moderately correlated with higher symptoms, lower functions of daily living, poorer quality of life, higher reported pain, and reduced return-to-sport confidence (p<0.05), but showed no significant association with squat asymmetry. Conversely, at late timepoints, lower TSK-11 scores (lower kinesiophobia) were moderately correlated with less pain, improved functions of daily living, more return-to-sport confidence, and greater quality of life (p<0.05). Mixed model analyses confirmed that higher kinesiophobia predicted significantly worse PROMs overall, especially at 4 months, with effects lessening by 12 months, and no significant relationship with squat asymmetry (Table 1).

Discussion: These results indicate that kinesiophobia is a significant factor influencing PROMs over the course of rehabilitation following ACLR with the strongest associations observed early in recovery. Individuals with higher TSK-11 scores reported poorer perceived knee function at early timepoints, highlighting the role of psychological barriers to recovery. Contrary to our hypothesis, squat asymmetry was not significantly associated with kinesiophobia, suggesting that compensatory limb-loading strategies during bilateral squats may not be captured fully by the measures employed in this study or may not directly impact PROMs. Ongoing analyses will further examine the relationship between limb-loading during phases of the squat and kinesiophobia.

Significance/Clinical Relevance: This study suggests that early identification and targeted management of kinesiophobia may be critical for optimizing PROMs following ACLR. Incorporating psychological assessment and interventions alongside standard physical rehabilitation protocols could improve long-term recovery outcomes within the ACLR population.

Table 1. Associations between kinesiophobia (TSK-11), limb-loading asymmetry, and patient-reported outcomes across recovery timepoints (N=39).

TSK-11 main effect	ACLR squat % (n=21)	Squat % difference with contralateral (n=21)	KOOS pain (n=39)	KOOS ADL (n=33)	KOOS symptoms (n=37)	KOOS Sport (n=39)	KOOS QOL (n=39)	IKDC (n=35)	ACL RSI (n=18)
Spearman correlation (95% CI)									
Early	-0.28 (-0.63, 0.17)	-0.07 (-0.49, 0.37)	-0.53 (-0.72, -0.26)	-0.48 (-0.71, -0.16)	-0.39 (-0.63, -0.07)	-0.52 (-0.72, -0.24)	-0.59 (-0.76, -0.34)	-0.59 (-0.77, -0.31)	-0.37 (-0.71, 0.12)
Late	0.00 (-0.43, 0.43)	0.17 (-0.28, 0.56)	-0.44 (-0.66, -0.15)	-0.51 (-0.72, -0.20)	-0.31 (-0.58, 0.02)	-0.62 (-0.78, -0.38)	-0.62 (-0.78, -0.38)	-0.71 (-0.84, -0.49)	-0.52 (-0.80, -0.08)
Mixed model									
TSK-11, +4 unit	<i>Beta (95% CI)</i>	<i>Beta (95% CI)</i>	<i>Beta (95% CI)</i>	<i>Beta (95% CI)</i>	<i>Beta (95% CI)</i>	<i>Beta (95% CI)</i>	<i>Beta (95% CI)</i>	<i>Beta (95% CI)</i>	<i>Beta (95% CI)</i>
Overall	-0.2 (-1.4, 1.0)	1.1 (-0.3, 2.6)		-2.4 (-3.6, -1.2)		-9.7 (-13.2, -6.2)	-9.6 (-13.0, -6.2)	-5.7 (-7.8, -3.6)	-101 (-147, -55.1)
4 months			-6.0 (-7.9, -4.1)		-6.6 (-9.3, -3.8)				
8 months			-4.0 (-5.8, -2.3)		-3.8 (-6.8, -0.9)				
12 months			-2.1 (-5.2, 1.0)		-1.1 (-6.2, 4.0)				

Beta=difference; CI=confidence interval;

Effects shown in **BOLD** if statistically significant at alpha=0.05; CI does not include zero.

Mixed linear regression modeling outcome

Interaction between TSK-11 and time tested and, if significant at 0.1 alpha level, TSK-11 effect shown by representative time points.