Preoperative and Early Postoperative Habitual Walking Speeds Predict 6 Month Knee Osteoarthritis-Related Symptoms Following Anterior Cruciate Ligament Reconstruction

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INTRODUCTION: Nearly half of individuals develop radiographic osteoarthritis (OA) within the first 2 decades of anterior cruciate ligament (ACL) injury regardless of undergoing ACL reconstruction (ACLR). Yet, there are limited clinical functional tools capable of predicting future OA development following ACLR, and the most current functional assessments involved in ACLR rehabilitation focus primarily on minimizing risk of reinjury for return to sport. Habitual walking speed is a clinically feasible and easily implemented tool that has promise for predicting future OA development. Slower habitual walking speed is associated with knee OA onset and progression in older adults. Cross-sectional, observational studies have found that ACLR individuals walk slower than uninjured controls, and slower walking speeds are associated with worse OA-related knee symptoms and deleterious changes to articular cartilage composition and joint tissue metabolism within the first 6-12 months following ACLR. Unfortunately, it is unknown whether habitual walking speed at timepoints when ACLR patients remain in clinical care and rehabilitation programs (i.e., preoperative and early postoperative timepoints) can predict OA-related knee symptoms at later timepoints post-ACLR when decisions are being made to transition patients to more dynamic movements. Therefore, the primary purpose of this study was to determine if habitual walking speed at preoperative, and 2 and 4 months post-ACLR timepoints associates with OA-related knee symptoms at 6 months post-ACLR. We also sought to determine critical thresholds and corresponding odds ratios for habitual walking speeds that best predict OA-related knee symptom status 6 months post-ACLR.

METHODS: Habitual overground walking speed was collected on ACLR patients at preoperative, and 2 and 4 months post-ACLR timepoints. Symptomatic status was determined at 6 months post-ACLR using the established Englund et al. (2003) cutoffs of the Knee Injury and Osteoarthritis Outcomes Score (KOOS). Separate receiver operating characteristic (ROC) curves and respective areas under the curve (AUC) were used to evaluate the capability of walking speed at each timepoint (preoperative, 2 and 4 months post-ACLR) to predict symptomatic status at 6 months post-ACLR (symptomatic vs asymptomatic). AUCs were considered statistically significant if the 95% confidence interval (CI) did not span 0.5. Walking speed threshold values were calculated from each statistically significant ROC curve; thresholds were determined as the points at which sensitivity and specificity were optimized on the ROC curves. Crude odds ratios for symptom status were calculated using 2x2 contingency tables from the determined walking speed threshold values.

RESULTS: Fifty-two individuals were included in the present analysis (n=30, 58% female; age: 22±4 years; BMI: 24.5±4.1 kg/m^2). Walking speed at the preoperative, and 2 and 4 months post-ACLR timepoints demonstrated moderate accuracy in predicting symptomatic status at 6 months post-ACLR (AUC: 0.66 [95% CI: 0.50-0.82], 0.66 [0.51-0.81], and 0.66 [0.51-0.82], respectively). Patients who walked ≤1.14 m/s at the preoperative timepoint demonstrated 7.46 (1.42-39.15) times higher odds of being symptomatic at 6 months. Patients who walked ≤1.16 m/s at 2 months post-ACLR demonstrated 7.66 (1.51-38.76) times higher odds of being symptomatic 6 months post-ACLR. At 4 months post-ACLR, individuals who walked ≤1.24 m/s demonstrated 7.67 (1.81-32.52) times higher odds of being symptomatic at 6 months post-ACLR.

DISCUSSION: Walking speed is an easily measured and implemented assessment which may aid in identifying individuals at preoperative and early postoperative timepoints who may be at greater risk for developing OA. We found that walking speeds at early ACLR timepoints (i.e., preoperative, and 2 and 4 months post-ACLR) demonstrated the capability to predict OA-related knee symptoms at 6 months post-ACLR. We determined walking speed thresholds of 1.14 m/s, 1.16 m/s, and 1.24 m/s at preoperative, and 2 and 4 months post-ACLR timepoints, respectively, to be speeds at which individuals demonstrate ~7.5 times higher odds of being symptomatic 6 months post-ACLR.

SIGNIFICANCE/CLINICAL RELEVANCE: Habitual walking speed may represent a clinically feasible assessment used for inclusion criteria for future clinical trials, benchmarks for success in rehabilitation protocols, and a screening tool to identify individuals most at-risk for future OA-related knee symptoms.

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IMAGES AND TABLES:

Table 1. Participant Demographics and KOOS Subscale Scores (Mean ± SD, or n (%), as appropriate)

Group	Sex, n (%) Female	Age, years	BMI, kg/m^2	KOOS Pain	KOOS Symptoms	KOOS ADL	KOOS Sport	KOOS QoL
All Participants (n=52)	30 (58)	21.5±4.4	24.5±4.1	85.1±10.0	79.2±12.8	95.8±7.2	67.1±18.9	54.1±17.6
Symptomatic (n=37)	21 (57)	21.9±4.2	24.6±4.0	81.3±9.2	74.6±12.0	94.3±8.1	60.0±16.8	48.5±14.8
Asymptomatic (n=15)	9 (60)	20.3±5.0	22.5±2.8	94.8±3.1	91.0±3.1	99.7±0.07	85.3±9.0	68.3±16.6

KOOS, Knee Injury and Osteoarthritis Outcomes Score; SD, Standard Deviation; ADL, Activities of Daily Living; QoL, Quality of Life

Table 2. Walking Speed, Symptom Status, Threshold Characteristics, and Odds Ratios for Each Timepoint Predicting 6 Months Symptom Status

Timepoint	Walking Speed, m/s	Symptomatic, n (%)	Asymptomatic, n (%)	Walking Speed Threshold, m/s (Sensitivity, Specificity)	Odds Ratio (95% CI)
Preoperative (n=46)	1.15±0.13	33 (72)	13 (28)	≤1.14 (0.56, 0.85)	7.46 (1.42-39.15)
2 Months Post-ACLR (n=52)	1.16±0.13	37 (71)	15 (29)	≤1.16 (0.54, 0.87)	7.66 (1.51-38.76)
4 Months Post-ACLR (n=50)	1.22±0.12	35 (70)	15 (30)	≤1.24 (0.66, 0.80)	7.67 (1.81-32.52)

ACLR, Anterior Cruciate Ligament Reconstruction; CI, Confidence Interval