Journal of Athletic Training 2024;59(12):1171–1177
doi: 10.4085/1062-6050-0617.23

www.natajournals.org

Associations Between Race and Socioeconomic Status, Lower Extremity Strength, and Patient-Reported Outcomes Following Anterior Cruciate Ligament Reconstruction

Nick W. Prinz*; Xavier D. Thompson, PhD, ATC†; Amelia S. Bruce Leicht, PhD, CSCS‡; Chris Kuenze, PhD, ATC†; Joe M. Hart, PhD, ATC§

*University of South Florida Morsani College of Medicine, Tampa; †Department of Kinesiology, University of Virginia, Charlottesville; ‡Department of Athletic Training and Clinical Nutrition, University of Kentucky, Lexington; §School of Medicine Department of Orthopaedics, University of North Carolina Chapel Hill; Dr Thompson is now at School of Kinesiology, Louisiana State University, Baton Rouge.

Context: There are significant disparities in access to health care, but there are limited data about the impact of race and socioeconomic status on postoperative outcomes following anterior cruciate ligament reconstruction (ACLR) surgery.

Objective: To identify associations between the Area Deprivation Index (ADI), strength measures, and patient-reported outcomes following ACLR and examine differences in outcomes between race, sex, and socioeconomic status.

Design: Case-control study in a single hospital setting.

Setting: Database secondary analysis.

Patients or Other Participants: Data were collected from 340 patients who underwent primary, isolated, unilateral ACLR.

Main Outcome Measure(s): Strength measures and patient-reported outcomes were obtained at patients' postoperative assessments at approximately 6 months postsurgery. Area Deprivation Index values were calculated on each patient's census tract, as determined through medical records review. Correlations were conducted to determine the relationship between the ADI and Knee Injury and Osteoarthritis Outcome Score measures, International Knee Documentation Committee, and limb symmetry on strength measurements. The racial composition of the sample was heavily skewed and was excluded from statistical analyses.

Results: The ADI was weakly correlated with International Knee Documentation Committee ($\rho = 0.11$, $P = .04$) outcomes, with more disadvantaged patients reporting better quality of life and knee function. The ADI was not correlated with other outcomes of interest. The median ADI value of the sample was 32 (range, 1–86 [interquartile range, 19–47]).

Conclusions: Our study revealed a weak correlation between higher levels of socioeconomic disadvantage as measured by the ADI and improved subjective assessment of knee function and quality of life as measured by International Knee Documentation Committee. These findings are contrary to what other studies on this subject have found and highlight the importance of further research into the impact of socioeconomic status and other social determinants of health on post-ACLR outcomes.

Key Words: social determinants of health, health disparities

Key Points

- Patients with a higher socioeconomic status had poorer subjective post–anterior cruciate ligament reconstruction outcomes as measured by the International Knee Documentation Committee.
- Timely interventions and sufficient rehabilitation are important factors for post–anterior cruciate ligament reconstruction recovery that can be affected by social determinants of health.

Anterior cruciate ligament (ACL) injury is one of the most common injuries of the knee. Surgical intervention to reconstruct the injured ligament is the standard of care for almost all individuals who suffer an ACL tear in North America, with many other countries opting for more conservative approaches, primarily physical therapy.[1,2] Individuals who undergo ACL reconstruction (ACLR) surgery are at risk for future ACL injuries, including both ipsilateral and contralateral injuries, relative to individuals without prior injury.[3] Factors that have been found to reduce the risk of reinjury following ACLR include sufficient time in physical rehabilitation and regaining quadriceps strength in the surgical leg to reach a comparable level as that of the uninjured leg.[3]

As knowledge of public health continues to grow, so too does the understanding that social determinants of health, such as socioeconomic status (SES), can have a significant

impact on health outcomes.[4] Lower SES has regularly been linked to a variety of poor health outcomes, including higher incidences of cancer, diabetes, heart disease, and overall mortality.[5] In addition to SES, racial and ethnic disparities in health care are also known to affect access to care.[6] Social determinants of health, including but not limited to level of education, family income, and food security, were found to be consistently worse in African American, Hispanic, American Indian, and Pacific Islander populations than in White populations.[7] Given the range of diseases and medical conditions that social determinants of health have been implicated in, it is reasonable to think that health outcomes in orthopedics may be affected as well.

There is some evidence that suggests a connection between race and ethnicity and incidence of ACL injuries, time from injury to ACLR, and outcomes following ACLR.[8] Although White patients are more likely to suffer ACL tears, non-White individuals are less likely to undergo ACLR following an ACL tear.[8] When controlling for insurance status, African American and Hispanic patients have longer delays before ACLR and are less likely to undergo ACLR than White patients.[8] It has also been shown that African American and other non-White patients had a greater risk for loss to follow-up at 2 years post-ACLR.[9] Additionally, African American and Hispanic patients attended fewer physical therapy sessions and had larger deficits in quadriceps and hamstring strength measures than White patients 9 months post-ACLR.[10] Unfortunately, the mechanisms to explain these racial disparities related to ACLR have not yet been determined.

Socioeconomic status has been shown to have a significant impact on health outcomes in both orthopedic and general patient populations, independent of race and ethnicity. Individuals of lower income, education, or occupational status experience worse health outcomes and have shorter lifespans than individuals of higher SES.[11] In a meta-analysis of health care disparities in orthopedics, social deprivation and race were independently linked to poorer access to health care, which was associated with delays in time to initial presentation, imaging, and surgery.[12] In patients who have undergone ACLR, previous research has demonstrated that lower neighborhood SES is associated with worse patient-reported outcomes (PROs; such as pain, symptoms, and quality of life) after ACLR.[13]

In both orthopedic and general population studies, there have been difficulties in measuring and quantifying SES. Socioeconomic status can be difficult to quantify given that there are a large number of factors that contribute to SES, such as education level, occupation, income, availability of quality housing, and access to quality health care. Prior studies investigating what effects patient SES may have on orthopedic outcomes have primarily used health insurance data and median household income levels or a patient's zip code as obtained from US Census Bureau data.[13–17] Although both of these measures can serve as good proxies for SES, they fail to fully encapsulate all of the factors that contribute to a patient's SES, such as educational, environmental, and financial opportunity. The Area Deprivation Index (ADI) is a metric that quantifies the level of socioeconomic disadvantage in a neighborhood based on 17 different factors from the US Census, including income, education, housing, and employment.[18] The ADI has previously been shown to be predictive of health outcomes in a variety of settings, including readmission risk following a hospital stay, neuropathological changes associated with Alzheimer's disease, and coronavirus disease 2019 in-hospital mortality.[18] In orthopedic settings, the ADI was shown to be associated with poorer compliance with post-fracture care, with more deprived patients being more likely to have delays in care and more likely to miss scheduled orthopedic visits.[19] Given the importance of sufficient rehabilitation following ACLR and the barriers that some patients may have in gaining access to these resources, it is possible that more disadvantaged patients may have poorer outcomes after ACLR. The primary purpose of this study was to identify associations between the ADI, PROs, and functional outcomes. The secondary purpose was to examine differences in outcomes between sex, race, and SES. We hypothesized that non-White patients and patients with lower national ADI values would have poorer lower extremity strength and poorer PROs at 6 months following ACLR.

METHODS

This was a single-site study including patients who had undergone an ACLR from a single hospital setting. Inclusion criteria included the ACL injury being the first ACL injury ever sustained by a patient, no other structural damage to the knee (ie, no other ligament damage), and an uncomplicated ACLR procedure, meaning no follow-up procedures such as revisions, debridements, or chondroplasties were performed. The patient's race was obtained from electronic medical record (EMR) data. Race was categorized following the same classifications as used by the EMR: American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino, White, and Other or Unknown. Patients were only able to select 1 option for their race within the EMR. Each patient's address from the EMR was used to determine ADI values. This study was approved by the local institutional review board, and all patients involved in this study provided informed consent.

Following ACLR at our institution, patients undergo standardized return to physical activity testing to monitor physical recovery and help establish a safe clearance for return to sport. Testing was completed based on referral by the treating surgeon and was typically completed for most patients initially at 3 to 4 months post-ACLR, with a follow-up assessment 5 to 8 months post-ACLR. The number of assessments varied between patients based on their willingness to complete testing as well as their rehabilitation progress, as patients who performed well were often not required to return. As part of their assessment, patients perform knee flexion and knee extension isokinetic strength testing as well as hop tests, including both single hops and triple hops. The strength and hopping metrics are then compared between the reconstructed and contralateral legs to establish a Limb Symmetry Index (LSI) between the 2 limbs. The LSI metric is calculated as (reconstructed limb value/contralateral limb value) $\times$ 100%. The LSI is expressed as a percentage, with 90% accepted as sufficient symmetry during strength and hopping tasks.[20]

Knee-Extensor and -Flexor Strength

Each patient completed concentric knee extension and flexion strength testing at 90°/s on a Biodex System 3

Dynamometer, a machine that measures isokinetic strength. Patients completed 8 repetitions of knee extension and 8 repetitions of knee flexion, and the peak knee extension and peak knee flexion torques were used for analysis, respectively. All testing was performed first on the uninvolved limb and then the involved limb. Participants completed practice trials on each limb to ensure familiarization before testing. We chose to analyze the peak instead of the average across trials because our primary interest is in evaluating maximal torque generating capacity of each muscle group. This approach has been widely used in the ACLR assessment literature.[21–23] Testing was always conducted on the uninvolved limb first followed by the involved limb.

Single-Legged Hopping

Patients also completed the single-leg hop for distance.[24] Each patient completed 3 single-leg hops per limb along a 6-m tape measure, alternating between the uninvolved and involved limb. Hop distance was measured from the beginning of the tape measure to the landing position of the heel, and the average distance of the 3 trials was used for analysis. If patients could not hold the landing position for at least 2 seconds, the test was repeated.

Patient-Reported Outcomes

All patients completed a battery of PROs during their assessment visit. The International Knee Documentation Committee (IKDC) was used to determine subjective knee function.[25] The IKDC consists of 3 categories: symptoms, athletic activity, and knee function.[25] The Knee Injury and Osteoarthritis Outcome Score (KOOS) was used to assess the severity of each patient's knee symptoms and functional disability.[26] The KOOS questionnaire consists of 5 measures: Pain, Symptoms, Activities of Daily Living, Sport and Recreation Function, and Knee-Related Quality of Life.[26] Each of these outcome measures is scored on a scale of 0 to 100, with 100 representing ideal status. Previous studies have found that both of these measures are correlated with post-ACLR outcomes. Regarding IKDC, prior work has shown that individuals who completed a full return to their pre-ACLR activity levels had higher IKDC scores than individuals who did not make a complete return to pre-ACLR activity levels.[27] The KOOS questionnaire has been found to be reliable and valid for evaluating patient progress following ACLR across multiple studies.[26,28]

Area Deprivation Index

The ADI is a measure that allows for stratification of geographic areas by socioeconomic disadvantage on both state and national levels. It includes measures for factors including income, education, employment, and housing quality.[18,29] The ADI has been used previously in a variety of settings, including, but not limited to, a predictive study regarding readmission to a large urban hospital and a retrospective review of mortality related to COVID 2019.[30,31] Specifically in orthopedic settings, the ADI has been correlated with worse pain and function scores as well as poorer outcome measures following pediatric orthopedic procedures.[12] The EMR was also used to determine each patient's current listed home address, which was then used to find their ADI. Area Deprivation Index values can range from 1 to 99, with higher numbers representing greater disadvantage and lower numbers indicating lesser disadvantage.

Statistical Analysis

All statistical analyses were performed in Stata 17 (StataCorp). Comparisons of categorical data were made via chi-squared analysis. Because continuous data were not normally distributed, sex comparisons were performed using Mann-Whitney U tests, and associations were calculated using Spearman ρ correlations using Stata 17 to determine covariance between ADI and KOOS measures, the IKDC, and limb symmetry on strength measurements.[32] Correlation coefficients were classified as *weak* (0.0–0.25), *fair* (0.26–0.50), *moderate* (0.51–0.75), and *strong* ($\geq$0.76).[33] The α level was set at $P < .05$.

RESULTS

Participants

A total of 340 participants following ACLR were enrolled in this study, with full demographic information displayed in Table 1. The population in this study was comprised of student-athletes as well as community members, with a large number of the participants being involved in athletics at some level. Four hundred sixty-three patients were initially included. One hundred twenty-three patients were excluded for lack of ADI, race, or KOOS data or for failing to meet the 3 ACLR criteria of being primary (first ever ACL injury), isolated (no other cartilage or ligament damage), and unilateral, leaving 340 patients (Figure 1).

The racial demographics of the sample are shown in Table 1. The median national ADI value of the sample was 32.5 (interquartile range, 19–47), with a minimum value of 1 and a maximum value of 86. Visualization of the distribution of the ADI can be found in Figure 2, and further patient demographics are available in Table 1.

Lower extremity strength, single-leg hop, and PRO measures are summarized in Table 2. The relationships between all measured variables and PROs with the ADI were examined. Only patient outcomes from the IKDC ($\rho = 0.11$, $P = .04$) were statistically significantly correlated with the ADI (Figure 3). The ADI was not statistically significantly correlated with knee extension LSI ($\rho = –0.09$, $P = .09$), knee flexion LSI ($\rho = –0.01$, $P = .89$), single-leg hop LSI ($\rho = –0.04$, $P = .54$), KOOS Symptoms ($\rho = 0.09$, $P = .10$), KOOS Pain ($\rho = 0.06$, $P = .28$), KOOS Activities of Daily Living ($\rho = 0.06$, $P = .28$), KOOS Sport ($\rho = 0.06$, $P = .24$), and KOOS Quality of Life ($\rho = 0.10$, $P = .06$).

DISCUSSION

Our results suggest that post-ACLR outcomes may be related to the degree of a patient's socioeconomic disadvantage as measured by the ADI, with more disadvantaged patients reporting better knee-related function and quality of life. As outcomes following ACLR have often been examined on the basis of sex demographic variables, PROs, strength, and hop data were compared by sex. Age, height, mass, and knee extension strength of the quadriceps varied by sex. There was a statistical difference in median age by sex of approximately 2 years, and both sexes showed unsatisfactory strength in quadriceps function using traditional

Table 1. Participant Demographics (Median ± SD)

	Total	Male	Female	Comparison by Sex *P* Value
n	340	164	176	
Race, *n* (%)[a]				
White	257 (75.6)	116 (70.7)	141 (80.1)	.12
African American	41 (12.1)	22 (13.4)	19 (10.8)	
Asian	6 (1.8)	2 (1.2)	4 (2.3)	
Hispanic	12 (3.5)	9 (5.5)	3 (1.7)	
Other	24 (7.0)	15 (9.2)	9 (5.1)	
Age, y	19.3 ± 9.5	20.4 ± 9.7	18.6 ± 9.3	<.001[b]
Height, cm	172.7 ± 10.2	177.8 ± 8.4	165.1 ± 7.1	<.001[b]
Mass, kg	71.9 ± 18.1	82.6 ± 18.6	63.5 ± 12.2	<.001[b]
Time since surgery, mo	7.1 ± 5.3	7.1 ± 5.9	7.3 ± 4.7	.71
ADI value, national %	33.0 ± 18.4	33.0 ± 18.5	32.0 ± 18.3	.51
Graft type, *n* (%)[a]				
Patella tendon	215 (63.2)	98 (59.8)	117 (66.5)	
Hamstring tendon	120 (35.3)	62 (37.8)	58 (33.0)	
Quadriceps tendon	3 (0.9)	2 (1.2)	1 (0.5)	
Allograft	0	0	0	
Not listed	2 (0.6)	2 (1.2)	0	

Abbreviation: ADI, Area Deprivation Index.
[a] Race and graft type are listed as the number of participants followed by the cumulative percentage within each respective graft type.
[b] Significant based on an α of $P \leq .05$.

LSI interpretations.[34] Therefore, it was determined that it would be appropriate to focus on the role of the ADI across both sexes in this sample.

The primary finding of this analysis was the inverse relationship between the ADI and IKDC score. These findings run contrary to much of the existing literature, which has generally shown poorer outcomes following orthopedic procedures in more disadvantaged patients.[12,13,19] Unfortunately, the mechanisms to explain these findings are unclear, although it warrants further investigation to determine what underlying factors may explain more disadvantaged patients having better PROs or if this finding is potentially due to reporting bias. It is important to note that statistically significant associations were observed between the ADI and only a small portion of PRO measures. There were no other statistically significant associations between the ADI and other outcomes of interest for this study, including other metrics for PRO measures and functional measures. Further, the associations that did exist between the ADI and PROs were classified as weak.

Although the ADI has been shown to be associated with outcomes in other areas of health care, it does not appear to

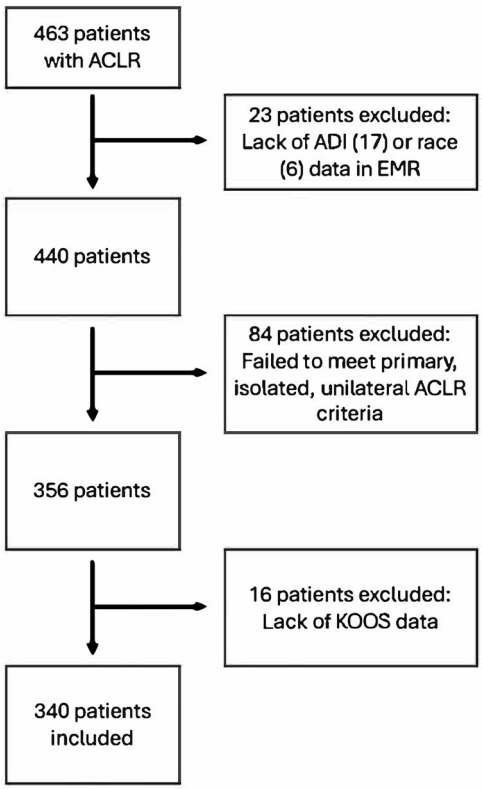

Figure 1. Flow chart of study participants. Abbreviations: ACLR, anterior cruciate ligament reconstruction; ADI, Area Deprivation Index; EMR, electronic medical record; KOOS, Knee injury and Osteoarthritis Outcome Score.

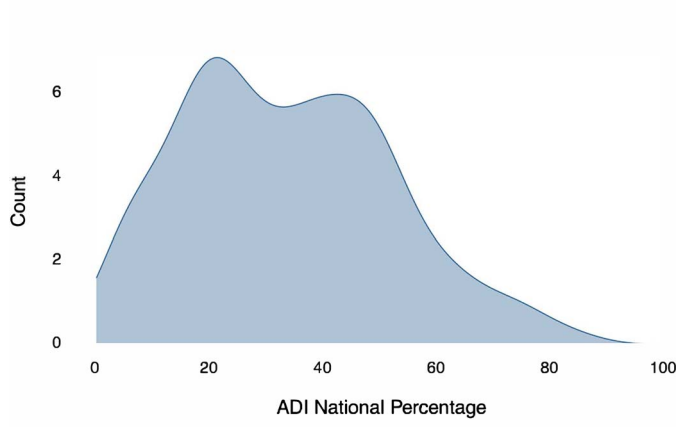

Figure 2. Distribution of Area Deprivation Index (ADI) values for all patients as determined by their listed addresses in their electronic medical record, with higher values indicating greater levels of disadvantage.

Table 2. Functional and Patient-Reported Outcomes (Median ± SD)

	Total	Male	Female	Comparison by Sex *P* Value
IKDC score	85.1 ± 13.2	86.2 ± 12.8	85.0 ± 13.6	.30
KOOS Symptoms	89.3 ± 13.2	89.3 ± 11.9	89.3 ± 14.3	.18
KOOS Pain	94.4 ± 10.3	94.4 ± 10.4	94.4 ± 10.3	.20
KOOS ADL	100.0 ± 6.7	100.0 ± 6.5	100.0 ± 6.9	.58
KOOS Sport	90.0 ± 17.3	90.0 ± 16.1	90.0 ± 18.3	.73
KOOS QOL	75.0 ± 20.3	75.0 ± 19.5	72.0 ± 21.0	.19
Knee extension LSI, %	75.6 ± 15.7	76.5 ± 15.8	74.5 ± 15.4	.02[a]
Knee flexion LSI, %	95.1 ± 18.1	96.9 ± 19.4	93.5 ± 16.7	.08
Single-leg hop LSI, %	93.7 ± 11.1	94.7 ± 11.0	93.0 ± 11.1	.13

Abbreviations: ADL, activities of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; LSI, limb symmetry index comparing the affected limb as a percentage of the unaffected limb; QOL, quality of life.
[a] Significance based on an α level of $P < .05$.

be well correlated with postoperative lower extremity strength measures and PROs following ACLR. Additionally, it is important to highlight that the measure found to be related to the ADI, IKDC, is a subjective, patient-reported measure, whereas all strength metrics used to gauge ACLR were found to have no correlation with the ADI. Given the skewed racial distribution of participants, we were not able to test the role of race as an independent predictor of post-ACLR outcomes or its interaction with the ADI. Relative to national demographics, White patients were overrepresented by roughly 15%, Hispanic patients were underrepresented by roughly 15%, and African American patients were underrepresented by 1.5% in our sample.[35]

The weak correlation between the ADI and post-ACLR outcomes may be impacted by the elective nature of the ACLR procedure. Given the economic and social burdens of undergoing ACLR, individuals of lower SES may be less likely to pursue this treatment option in situations where it is not deemed necessary or if they do not have the financial stability to afford the costs of surgery and sufficient physical therapy and missed time from work. It is also possible that the decreased number of more disadvantaged patients within this sample could reflect an inability for this patient population to see a physician or physical therapist if they do sustain an ACL injury. An additional possibility is that patients with higher ADI values may have lower levels of involvement in sports and other activities that have increased potential for causing ACL injuries. Socioeconomic barriers that can limit sports involvement include cost, household factors such as material deprivation, and neighborhood factors such as lack of access.[36]

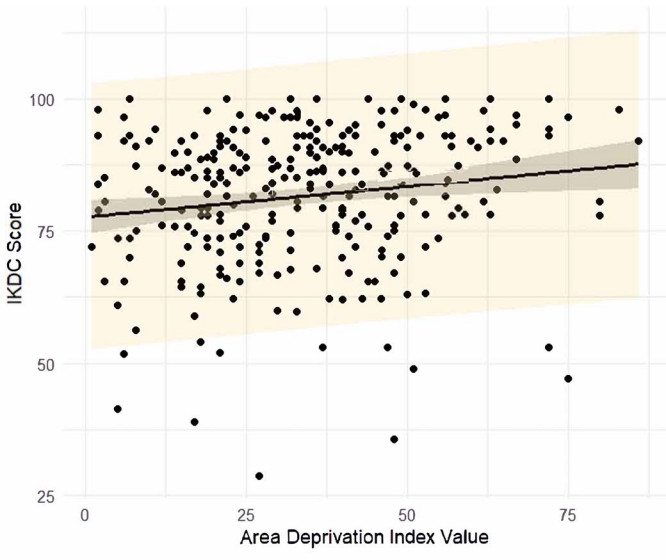

Figure 3. The relationship between the International Knee Documentation Committee (IKDC) score and the Area Deprivation Index. The correlation between them was poor ($\rho = 0.11$) although significant ($P = .04$).

Previous studies in this area have yielded mixed evidence regarding the strength of relationships between race, SES, social determinants of health, and postoperative ACLR outcomes.[9,10,37,38] Prior research has suggested that patients of lower SES have poorer post-ACLR outcomes than patients of higher SES.[13] Although much of the existing literature consistently points to lower SES resulting in poorer outcomes following ACLR, there is less conclusive evidence regarding the correlation between race and post-ACLR outcomes. In 1 study, African American and Hispanic patients were found to have greater deficits in strength during rehabilitation and a greater risk for hospital admission following ACLR than White patients.[8] However, there are other studies that found that African American, Asian, and Hispanic patients had a lower risk of future ACLR after an initial surgery than White patients.[37] Previously published studies have found no differences in post-ACLR outcomes between races. One study found that, despite African American and Hispanic patients averaging fewer physical therapy visits than White patients, there was no difference in postoperative outcomes, namely graft rupture, a contralateral ACL injury, or a new meniscus injury, between races.[10] Ultimately, it appears that more work is needed to fully realize what impact, if any, race has on post-ACLR outcomes.

A potential area for future work is the collection of insurance data, as this may allow for a more accurate assessment of an individual's ability to access care and rehabilitation resources following ACLR. Insurance data were not included in this patient sample, as a significant portion of the patients did not have verifiable insurance information in their EMR. Prior work regarding insurance status and its association with post-ACLR outcomes is more robust than the ADI and other measures of SES. Patients using government insurance as opposed to private insurance experienced greater delays in time from injury to first appointment, injury to surgery, and injury to return to play.[39] As mentioned earlier, both spending sufficient time in physical rehabilitation and regaining sufficient

strength have been shown to reduce the likelihood of reinjury following ACLR. However, the rehabilitation resources needed to achieve these benchmarks are not readily available to all patients. When comparing patients using private insurance and public insurance, those who used private insurance received magnetic resonance imaging twice as fast after their injury and underwent ACLR almost 40% faster than publicly insured patients.[40] Patients using Medicaid insurance had their coverage accepted at almost 50% fewer physical therapy clinics than patients who used private insurance and had to wait 3 days more on average than privately insured patients before their initial physical therapy visit.[41] In addition to attending fewer postoperative physical therapy sessions, patients using Medicaid were less likely to return to sport following ACLR than privately insured patients.[42] Another potential area for future study is the inclusion of data from other institutions that serve more diverse patient populations to better determine any impact that race and the ADI may have on post-ACLR outcomes.

Limitations

One of the primary limitations of this study was the homogeneity of the sample population, with over three-quarters of the patients being White and a median national ADI value of 32.5. These findings are not entirely surprising, as they mirror the demographics of the population surrounding the institution from which the sample population was recruited. Based on the most recent census data, the racial demographics of the metropolitan area surrounding the institution are as follows: 74% White, 10% African American, 4% Asian, 6% Hispanic, and 4% identifying as 2 or more races.[43] Another limitation was that the ADI, although correlated with many different health outcomes both in our study and others, may not fully encapsulate an individual's SES and ability to access care following ACL injuries and ACLR. Additionally, the ADI is not able to capture factors such as a patient's insurance status or baseline strength and activity level, all of which may impact post-ACLR outcomes either directly or indirectly.[44] Another limitation of the ADI is that it is based upon the address provided by the patient. At an academic institution like ours that serves many individuals who are attending college, the address listed may be the address of their student housing and thus not an accurate representation of their ADI. In our sample, 150 individuals were between the ages of 18 and 22, presumably many of whom were attending college and not living at their home address. Given that the area surrounding our institution is largely comprised of low ADI values, the average ADI of our sample may be lower than it would have been if students had used their home address.

CONCLUSIONS

Ultimately, patient ADI values were found to have statistically significant, although weak, correlations with IKDC measures. These results suggest that patients of greater socioeconomic disadvantage have better post-ACLR outcomes as measured by the IKDC. Other outcomes of interest regarding patient strength and PROs were not found to have a statistically significant relationship with the ADI. Although this is potentially an encouraging finding, it remains true that timely interventions following ACL tears and having sufficient rehabilitation are important factors in maximizing patient outcomes following ACLR, and some patients will be limited in their ability to access these resources. It is important to remain cognizant of the disparities that exist across many areas of health care, including orthopedics, and continue to work toward more equitable access to health care for all individuals.

REFERENCES

1. Kiapour AM, Murray MM. Basic science of anterior cruciate ligament injury and repair. *Bone Joint Res*. 2014;3(2):20–31. doi:10.1302/2046-3758.32.2000241
2. Filbay SR, Grindem H. Evidence-based recommendations for the management of anterior cruciate ligament (ACL) rupture. *Best Pract Res Clin Rheumatol*. 2019;33(1):33–47. doi:10.1016/j.berh.2019.01.018
3. Grindem H, Snyder-Mackler L, Moksnes H, Engebretsen L, Risberg MA. Simple decision rules can reduce reinjury risk by 84% after ACL reconstruction: the Delaware-Oslo ACL cohort study. *Br J Sports Med*. 2016;50(13):804–808. doi:10.1136/bjsports-2016-096031
4. Braveman P, Gottlieb L. The social determinants of health: it's time to consider the causes of the causes. *Public Health Rep*. 2014;129(Suppl 2):19–31. doi:10.1177/00333549141291S206
5. Flaskerud JH, DeLilly CR. Social determinants of health status. *Issues Ment Health Nurs*. 2012;33(7):494–497. doi:10.3109/01612840.2012.662581
6. Smedley BD, Stith AY, Nelson AR. *Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care*. National Academy Press; 2003.
7. Ndugga N, Hill L, Artiga S. Key data on health and health care by race and ethnicity. KFF. Published June 11, 2024. Accessed October 15, 2024. https://www.kff.org/racial-equity-and-health-policy/report/key-facts-on-health-and-health-care-by-race-and-ethnicity/
8. Devana SK, Solorzano C, Nwachukwu B, Jones KJ. Disparities in ACL reconstruction: the influence of gender and race on incidence, treatment, and outcomes. *Curr Rev Musculoskelet Med*. 2022;15(1):1–9. doi:10.1007/s12178-021-09736-1
9. Ramkumar PN, Tariq MB, Amendola A; MOON Knee Group. Risk factors for loss to follow-up in 3202 patients at 2 years after anterior cruciate ligament reconstruction: implications for identifying health disparities in the MOON prospective cohort study. *Am J Sports Med*. 2019;47(13):3173–3180. doi:10.1177/0363546519876925
10. Bram JT, Talathi NS, Patel NM, DeFrancesco CJ, Striano BM, Ganley TJ. How do race and insurance status affect the care of pediatric anterior cruciate ligament injuries? *Clin J Sport Med*. 2020;30(6):e201–e206. doi:10.1097/JSM.0000000000000706
11. Fiscella K, Williams DR. Health disparities based on socioeconomic inequities: implications for urban health care. *Acad Med*. 2004;79(12):1139–1147. doi:10.1097/00001888-200412000-00004
12. Arant KR, Modest JM, Gil JA, Cruz AI Jr. What's new in pediatric orthopaedic health care disparities? *J Pediatr Orthop*. 2022;42(9):e954–e959. doi:10.1097/BPO.0000000000002224
13. Jones MH, Reinke EK, Zajichek A, et al; MOON Knee Group. Neighborhood socioeconomic status affects patient-reported outcome 2 years after ACL reconstruction. *Orthop J Sports Med*. 2019;7(6):2325967119851073. doi:10.1177/2325967119851073
14. Alvarez PM, McKeon JF, Spitzer AI, et al. Socioeconomic factors affecting outcomes in total knee and hip arthroplasty: a systematic review on healthcare disparities. *Arthroplasty*. 2022;4(1):36. doi:10.1186/s42836-022-00137-4
15. Barrie U, Montgomery EY, Ogwumike E, et al. Household income as a predictor for surgical outcomes and opioid use after spine surgery in the United States. *Global Spine J*. 2023;13(8):2124–2134. doi:10.1177/21925682211070823
16. Strotman P, Perry M, LeDuc R, Joyce C, Garbis N. Effect of insurance status on clinical outcomes after shoulder arthroplasty. *Orthopedics*. 2020;43(6):e523–e528. doi:10.3928/01477447-20200827-02

17. Veltre DR, Sing DC, Yi PH, et al. Insurance status affects complication rates after total hip arthroplasty. *J Am Acad Orthop Surg*. 2019;27(13):e606–e611. doi:10.5435/JAAOS-D-17-00635
18. Center For Health Disparities Research. Neighborhood Atlas. Accessed December 2, 2022. https://www.neighborhoodatlas.medicine.wisc.edu/
19. Meza BC, Iacone D, Talwar D, Sankar WN, Shah AS. Socioeconomic deprivation and its adverse association with adolescent fracture care compliance. *JB JS Open Access*. 2020;5(2):e0064. doi:10.2106/JBJS.OA.19.00064
20. Farmer B, Anderson D, Katsavelis D, Bagwell JJ, Turman KA, Grindstaff TL. Limb preference impacts single-leg forward hop limb symmetry index values following ACL reconstruction. *J Orthop Res*. 2022;40(1):200–207. doi:10.1002/jor.25073
21. Thompson XD, Bruce Leicht AS, Hopper HM, et al. Knee extensor torque-velocity relationships following anterior cruciate ligament reconstruction. *Clin Biomech (Bristol, Avon)*. 2023;108:106058. doi:10.1016/j.clinbiomech.2023.106058
22. Sroufe MD, Sumpter AE, Thompson XD, et al. Comparison of patient-reported outcomes, strength, and functional performance in primary versus revision anterior cruciate ligament reconstruction. *Am J Sports Med*. 2023;51(8):2057–2063. doi:10.1177/03635465231169535
23. Bodkin SG, Hertel J, Diduch DR, et al. Predicting anterior cruciate ligament reinjury from return-to-activity assessments at 6 months postsurgery: a prospective cohort study. *J Athl Train*. 2022;57(4):325–333. doi:10.4085/1062-6050-0407.20
24. Logerstedt D, Grindem H, Lynch A, et al. Single-legged hop tests as predictors of self-reported knee function after anterior cruciate ligament reconstruction: the Delaware-Oslo ACL cohort study. *Am J Sports Med*. 2012;40(10):2348–2356. doi:10.1177/0363546512457551
25. Irrgang JJ, Anderson AF. Development and validation of health-related quality of life measures for the knee. *Clin Orthop Relat Res*. 2002;402:95–109. doi:10.1097/00003086-200209000-00009
26. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)—development of a self-administered outcome measure. *J Orthop Sports Phys Ther*. 1998;28(2):88–96. doi:10.2519/jospt.1998.28.2.88
27. Toole AR, Ithurburn MP, Rauh MJ, Hewett TE, Paterno MV, Schmitt LC. Young athletes cleared for sports participation after anterior cruciate ligament reconstruction: how many actually meet recommended return-to-sport criterion cutoffs? *J Orthop Sports Phys Ther*. 2017;47(11):825–833. doi:10.2519/jospt.2017.7227
28. Salavati M, Akhbari B, Mohammadi F, Mazaheri M, Khorrami M. Knee injury and Osteoarthritis Outcome Score (KOOS); reliability and validity in competitive athletes after anterior cruciate ligament reconstruction. *Osteoarthritis Cartilage*. 2011;19(4):406–410. doi:10.1016/j.joca.2011.01.010
29. Kind AJH, Buckingham WR. Making neighborhood disadvantage metrics accessible: the Neighborhood Atlas. *New Engl J Med*. 2018;378(26):2456–2458. doi:10.1056/NEJMp1802313
30. Hu J, Kind AJH, Nerenz D. Area Deprivation Index predicts readmission risk at an urban teaching hospital. *Am J Med Qual*. 2018;33(5):493–501. doi:10.1177/1062860617753063
31. Hu J, Bartels CM, Rovin RA, Lamb LE, Kind AJH, Nerenz DR. Race, ethnicity, neighborhood characteristics, and in-hospital coronavirus disease-2019 mortality. *Med Care*. 2021;59(10):888–892. doi:10.1097/MLR.0000000000001624
32. StataCorp. *Stata Statistical Software: Release 17*. Version 17. StataCorp LLC; 2021. https://www.stata.com/
33. Kapan A, Ristic M, Yang L, Kranz G, Waldhör T. Concurrent validity and test-retest reliability of the 3-meter backward walk test in stroke survivors. *Healthcare (Basel)*. 2023;11(23):3020. doi:10.3390/healthcare11233020
34. Rohman E, Steubs JT, Tompkins M. Changes in involved and uninvolved limb function during rehabilitation after anterior cruciate ligament reconstruction: implications for Limb Symmetry Index measures. *Am J Sports Med*. 2015;43(6):1391–1398. doi:10.1177/0363546515576127
35. US Census Bureau quickfacts: United States. United States Census Bureau. Accessed June 26, 2023. https://www.census.gov/quickfacts/fact/table/US/PST045222
36. Owen KB, Nau T, Reece LJ, et al. Fair play? Participation equity in organised sport and physical activity among children and adolescents in high income countries: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act*. 2022;19(1):27. doi:10.1186/s12966-022-01263-7
37. Gallo MC, Bolia IK, Jalali O, et al. Risk factors for early subsequent (revision or contralateral) ACL reconstruction: a retrospective database study. *Orthop J Sports Med*. 2020;8(2):2325967119901173. doi:10.1177/2325967119901173
38. Pullen WM, Bryant B, Gaskill T, Sicignano N, Evans AM, DeMaio M. Predictors of revision surgery after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2016;44(12):3140–3145. doi:10.1177/0363546516660062
39. Patel AR, Smith R, Gupta K, Vandenberg C. Socioeconomic status impacts outcomes following anterior cruciate ligament reconstruction status. *Orthop J Sports Med*. 2018;6(7 suppl 4):2325967118S00104. doi:10.1177/2325967118S00104
40. Khanna K, Janghala A, Pandya NK. The effect of insurance status and race on access to care for pediatric and adolescent patients with anterior cruciate ligament injury. *J Health Dispar Res Pract*. 2018;11(2):Article 6.
41. Rogers MJ, Penvose I, Curry EJ, DeGiacomo A, Li X. Medicaid health insurance status limits patient accessibility to rehabilitation services following ACL reconstruction surgery. *Orthop J Sports Med*. 2018;6(4):2325967118763353. doi:10.1177/2325967118763353
42. Chava NS, Fortier LM, Verma N, et al. Patients with Medicaid insurance undergoing anterior cruciate ligament reconstruction have lower postoperative International Knee Documentation Committee scores and are less likely to return to sport than privately insured patients. *Arthroscopy Sports Med Rehabil*. 2002;4(4):e1457–e1464. doi:10.1016/j.asmr.2022.05.005
43. Census profile: Charlottesville, VA Metro Area. Census Reporter. Accessed June 26, 2023. https://censusreporter.org/profiles/31000US16820-charlottesville-va-metro-area/
44. Kim DK, Park G, Wang JH, Kuo L-T, Park WH. Preoperative quadriceps muscle strength deficit severity predicts knee function one year after anterior cruciate ligament reconstruction. *Sci Rep*. 2022;12(1):5830. doi:10.1038/s41598-022-09816-3

Address correspondence to Xavier D. Thompson, PhD, ATC, School of Kinesiology, 50 Field House Drive, Louisiana State University, Baton Rouge, LA 70802. Address email to xthompson@lsu.edu.