Neighborhood Socioeconomic Status Affects Patient-Reported Outcome 2 Years After ACL Reconstruction

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Background: Lower socioeconomic status (SES) is associated with worse patient-reported outcome (PRO) after orthopaedic procedures. In patients with anterior cruciate ligament (ACL) reconstruction, evaluating SES by use of traditional measures such as years of education or occupation is problematic because this group has a large proportion of younger patients. We hypothesized that lower education level and lower values for SES would predict worse PRO at 2 years after ACL reconstruction and that the effect of education level would vary with patient age.

Purpose: To compare the performance of multivariable models that use traditional measures of SES with models that use an index of neighborhood SES derived from United States (US) Census data.

Study Design: Cohort study; Level of evidence, 3.

Methods: A cohort of 675 patients (45% female; median age, 20 years), were prospectively enrolled and evaluated 2 years after ACL reconstruction with questionnaires including the International Knee Documentation Committee (IKDC) questionnaire, the Knee injury and Osteoarthritis Outcome Score (KOOS), and the Marx activity rating scale (Marx). In addition, a new variable was generated for this study, the SES index, which used geocoding performed retrospectively to identify the census tract of residence for each participant at the time of enrollment and extract neighborhood SES measures from the 2000 US Census Descriptive Statistics. Multivariable models were constructed that included traditional measures of SES as well as the SES index, and the quality of models was compared through use of the likelihood ratio test.

Results: Lower SES index was associated with worse PRO for all measures. Models that included the SES index explained more variability than models with traditional SES. In addition, a statistically significant variation was found regarding the impact of education on PRO based on patient age for the IKDC score, the Marx scale, and 4 of the 5 KOOS subscales.

Conclusion: This study demonstrates that lower neighborhood SES is associated with worse PRO after ACL reconstruction and that age and education have a significant interaction in this patient population. Future studies in patients who have undergone ACL reconstruction should attempt to account for neighborhood SES when adjusting for confounding factors; further, targeting patients from areas with lower neighborhood SES with special interventions may offer an opportunity to improve their outcomes.

Keywords: anterior cruciate ligament reconstruction; socioeconomic status; clinical outcomes

When the effects of medical treatment, the effects of surgical treatment, or the propensity to develop a disease are evaluated, the consideration of socioeconomic status (SES) is essential. Different socioeconomic factors are known to affect health through numerous causal pathways.[4] For example, it has been found that people with low SES experience more dysfunction in multiple biological systems compared with people who have higher SES.[3] Furthermore, neighborhood SES has been shown in many studies to correlate with the observed measure of health more strongly than common individual socioeconomic factors.[8,9] Within the realm of orthopaedic surgery, several retrospective studies have identified associations between SES and important aspects of total joint arthroplasty.[11,14,15,19] Mahomed et al[15] found SES to be indirectly related to mortality and wound infection following total hip arthroplasty. SooHoo et al[18] found that patients insured with Medicaid had higher odds of having an infection following a total knee arthroplasty than those with private insurance.

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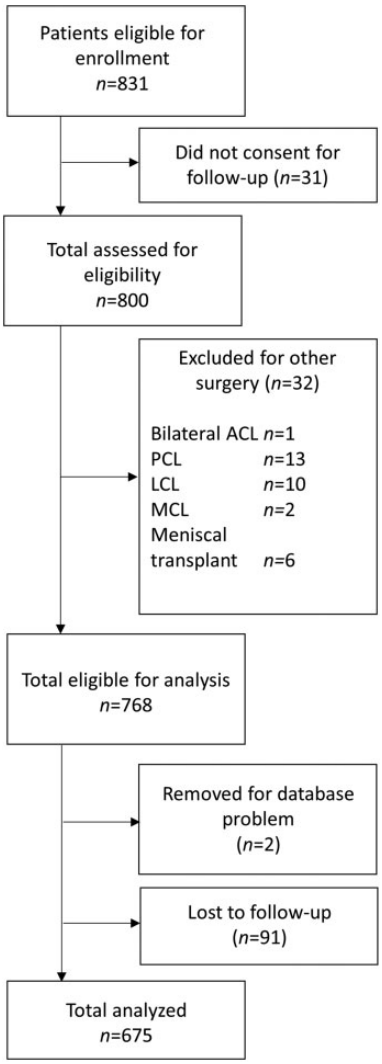

Figure 1. Patient enrollment flow diagram. ACL, anterior cruciate ligament; LCL, lateral collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament.

Anterior cruciate ligament (ACL) reconstruction can effectively restore knee stability and allow patients to return to sporting activities, but not all patients have the same improvement in patient-reported outcome (PRO) after surgery. For example, certain factors such as younger age and use of allograft have been associated with higher failure rates and a worse PRO.[6,12] In addition, socioeconomic variables including race and education level have been significant predictors of outcome in previous studies from our cohort.[6] However, a growing body of evidence suggests that neighborhood SES can be used as a proxy for individual SES and that a person's health may be influenced more by neighborhood SES than individual-level SES.[3,7-9] In addition, the young age of patients who have ACL reconstruction makes the use of education level as a predictor of SES problematic. Many of these patients are students, so their final education level has not yet been attained. Because education level increases with age in children and young adults, any findings attributed to this variable may be confounded by age until students complete their education.

The purpose of this study was to clarify the relationships between age, education level, neighborhood SES, and PRO after ACL reconstruction. We hypothesized that lower education level and lower neighborhood SES would predict worse PRO at 2 years after ACL reconstruction and that the relationship between education level and PRO would vary depending on patient age. We also hypothesized that models including neighborhood SES would explain more variation than models without these variables.

TABLE 1
Components of the Socioeconomic Status (SES) Index

SES Index Variable	2000 US Census Data Source (https://www.census.gov/data.html)
Median household income	Median household income in 1999 (table P53)
Median value of housing units	Median value for all owner-occupied housing units (table H85)
% of households with interest, dividend, rental income	Household interest, dividends, or net rental income in 1999 (table P61)
% of residents over 25 with high school education	Educational attainment by sex for the population 25 years and older (table P37)
% of residents over 25 with complete college education	Educational attainment by sex for the population 25 years and older (table P37)
% of residents in executive, management, or professional job	Occupation by sex for the employed civilian population 16 years and older (table P50)

METHODS

The Multicenter Orthopaedic Outcomes Network (MOON) is a prospective, multicenter cohort study that began enrolling patients at 7 sites in 2002. Details of the study design have

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TABLE 2
Descriptive Summary of the Cohort (N = 675)[a]

Variable	% or Median (Q1, Q3)	Variable	% or Median (Q1, Q3)
Demographics		SES factors	
Age, y	20 (17, 33)	Education, y	13 (11, 16)
Male sex	55	Employment status	
Race		None	58
White	85	Part-time	11
Black	10	Full-time	31
Other	5	Student	53
BMI	24.4 (22.2, 27.8)	Disability	4
Smoking status		SES index	–0.49 (–2.98, 2.7)
Never	79	Clinical factors	
Quit	10	Graft	
Current	11	BTB autograft	60
Sport at injury		Hamstring autograft	29
None	17	Allograft	12
Basketball	25	Lateral meniscal tear severity	
Football	16	No tear	51
Soccer	14	Partial tear	34
Other	28	Complete tear	14
Competition level		Medial meniscal tear treatment	
None	5	None	68
Recreational	46	Excision	16
Competitive	50	Repair	17
No. of people in household	2 (1, 3)	Lateral meniscal tear treatment	
		None	66
		Excision	27
		Repair	6
		Surgery type	
		Primary	93
		Revision	7

[a]BMI, body mass index; BTB, bone–patellar tendon–bone; Q1, first quartile; Q3, third quartile; SES, socioeconomic status.

been previously published.[6,10] Patient questionnaires were administered at baseline and 2 years postsurgery. Evaluation of later outcomes becomes more complex because patients are more likely to move and live in different neighborhoods 6 and 10 years after surgery, so we chose to focus on 2-year outcomes for this project. The validated outcome instruments included the International Knee Documentation Committee (IKDC) questionnaire, the Knee injury and Osteoarthritis Outcome Score (KOOS), and the Marx activity rating scale (Marx), and general questions included age, sex, race-ethnicity, height, weight, occupation, and years of education. Surgeon questionnaires were completed after surgery and included documentation of examination under anesthesia, arthroscopic findings, and details of the treatment such as graft choice, fixation technique, and meniscal and articular cartilage abnormalities and treatment. Rehabilitation was standardized across the cohort through use of an evidence-based rehabilitation protocol. Enrolling surgeons participated in a cadaveric study that established their ability to appropriately place tunnels regardless of surgical technique.[20]

This study included patients from 2 of the MOON sites (Cleveland Clinic, Cleveland, Ohio, and Vanderbilt University Medical Center, Nashville, Tennessee) from the 2002 to 2004 enrollment years (Figure 1). Additional sites could not be included because of limitations placed by local institutional review boards on the use of protected health information (census data tract, in particular).

SES Calculation

Neighborhood SES was appraised through the use of geocoding, using ArcGIS 10.1 (Environmental Systems Research Institute) to plot a patient's address on a map and determine which census tract contains the address. Census tracts are small subdivisions of a county that usually contain between 2500 and 8000 persons; in a sense, census tracts are analogous to large neighborhoods. Census tracts are designed to be homogenous with respect to population characteristics, economic status, and living conditions. Once the census tract for each address was determined, descriptive statistics provided by the 2000 United States (US) Census were retrieved and used as a proxy for the SES of patients who lived within the respective census tracts. Because many of the variables from the US Census are overlapping and highly correlated, factor analysis was used to identify 6 largely uncorrelated variables that contribute to SES (Table 1). These variables were joined by summing their z scores (the number of standard deviations from the mean for each measurement) and were used as a composite index of SES.[3,4,7-9]

TABLE 3
Outcome Scores at Baseline and 2-Year Follow-up[a]

Outcome Measure	Baseline	2-y Follow-up
KOOS ADL	88.2 (73.5, 97.1)	98.5 (94.1, 100)
KOOS QoL	37.5 (25, 50)	75 (62.5, 87.5)
KOOS Symptoms	71.4 (57.1, 82.1)	85.7 (75, 92.9)
KOOS Pain	75 (63.9, 88.9)	94.4 (86.1, 97.2)
KOOS Sports&Rec	50 (30, 75)	85 (70, 95)
Marx	13 (8, 16)	10 (5, 14)
IKDC	52.9 (41.4, 65.5)	85.1 (74.7, 93.1)

[a]Data are reported as median (1st quartile, 3rd quartile). ADL, activities of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; QoL, Quality of Life; Sports&Rec, Sports and Recreation.

Statistical Analysis

Sequential models were constructed to better understand the additional effect of both standard socioeconomic variables (education, employment status, student status, disability status, and interaction of age and education) and neighborhood SES (SES index) on PRO (IKDC, KOOS subscales, and Marx scores).

A parsimonious clinical model was initially constructed to predict PRO scores based on demographic variables and details of physical examination, surgical findings, and surgical technique that were significant predictors in prior studies.[6,10] These variables included age, sex, race, body mass index, smoking status, sport played at the time of injury, competition level, graft type, primary versus revision surgery, lateral meniscal tear severity, and baseline outcome score.

Next, variables that have traditionally been used as a proxy for SES were added to the model. These included years of education, employment status (full-time, part-time, and unemployed), student status, and disability status. A variable to test the interaction of age and education was also included because many patients in the cohort were not old enough to have completed their education. The corrected Akaike information criterion (AICc), a measure of the relative quality of statistical models corrected for sample size, was calculated for each model. A general rule is that a difference of 2 or more in the AICc indicates a statistically better model.[1,5] In addition, hypothesis testing was performed by use of the likelihood ratio test, with $P < .05$ indicating a significant difference in models.

The SES index was calculated for each patient as follows: Each patient's home address at baseline was mapped through use of ArcGIS software to determine the census tract for each address and link to the relevant statistics from the 2000 US Census. The 6 SES index variables and corresponding US Census statistics are listed in Table 1. Next, the variables were transformed so that higher values represented higher SES and were normalized by calculating a z score for each variable and summing the z scores for each variable to create a summary score, the SES index.

Next, the SES index variable was tested to see whether it improved the performance of the models. For outcome measures where the addition of the traditional SES variables improved model performance, the SES index was added to the model to see whether it provided any improvement in performance over the traditional SES variables. For outcome measures where the traditional SES variables did not improve model performance, the SES index variable was added to the clinical model and model performance was evaluated. As in the previous step, models were compared by use of the difference in AICc and the likelihood ratio test.

TABLE 4
Comparison of the Clinical Model
With Models Including SES Variables[a]

Outcome Measure and Model	*P*	AICc
KOOS ADL		
Clinical	<.001	4554.35
Clinical + A	.004	4548.51
Clinical + A + B	**.001**	**4538.93**
KOOS QoL		
Clinical	<.001	5590.86
Clinical + A	.005	5585.19
Clinical + A + B	**.036**	**5582.99**
KOOS Pain		
Clinical	<.001	4899.24
Clinical + A	.041	4899.12
Clinical + A + B	**.01**	**4894.71**
KOOS Sports&Rec		
Clinical	<.001	5137.48
Clinical + A	.137	5140.84
Clinical + B	**.01**	**5132.96**
KOOS Symptoms		
Clinical	<.001	5109.19
Clinical + A	.513	5116.95
Clinical + B	**.054**	**5107.61**
Marx		
Clinical	<.001	3602.54
Clinical + A	.001	3591.46
Clinical + A + B	**.006**	**3586.12**
IKDC		
Clinical	<.001	5045.44
Clinical + A	.074	5046.95
Clinical + B	**.001**	**5037.46**

[a]The traditional SES variables are labeled "A" and include education, employment status, student status, disability status, and interaction of age and education. The neighborhood-level SES variable is the SES index and is labeled "B." Bolded text highlights the best model according to the AICc and *P* values from likelihood ratio tests. ADL, activities of daily living; AICc, corrected Akaike Information Criterion; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; QoL, Quality of Life; SES, socioeconomic status; Sports&Rec, Sports and Recreation.

RESULTS

Table 2 shows univariate baseline characteristics of the cohort. The cohort contained 675 patients; 45% were female, and the median age was 20 years. Table 3 shows the outcome scores at baseline and 2-year follow-up.

Table 4 shows the results of the model comparisons for each outcome measure (KOOS subscales, Marx, IKDC).

TABLE 5
Coefficients and *P* Values for the Best Model for KOOS ADL and QoL Outcomes[a]

	KOOS ADL		KOOS QoL	
Variable	Effect (95% CI)	*P*	Effect (95% CI)	*P*
Age	–0.39 (–0.77 to –0.02)	**.039**	–1.03 (–1.89 to –0.17)	**.019**
Sex				
Female	—	—	—	—
Male	–0.39 (–1.95 to 1.16)	.619	–1.35 (–4.92 to 2.22)	.457
Race				
White	—	—	—	—
Black	1.19 (–1.55 to 3.93)	.395	0.27 (–6.04 to 6.58)	.933
Other	–0.03 (–3.74 to 3.67)	.987	1.12 (–7.39 to 9.63)	.796
BMI	0 (–0.18 to 0.19)	.959	–0.48 (–0.89 to –0.07)	**.022**
Smoking status				
Never	—	—	—	—
Quit	0.26 (–2.37 to 2.89)	.847	–6.86 (–12.85 to –0.87)	**.025**
Current	–4.4 (–7.11 to –1.69)	**.001**	–7.36 (–13.57 to –1.15)	**.02**
Competition level				
None	—	—	—	—
Recreational	0.1 (–4.04 to 4.25)	.962	–5.84 (–15.28 to 3.59)	.224
Competitive	0.51 (–4.16 to 5.18)	.83	–3.25 (–13.92 to 7.41)	.55
Graft				
BTB autograft	—	—	—	—
Hamstring autograft	0.07 (–1.79 to 1.94)	.937	0.74 (–3.57 to 5.06)	.735
Allograft	2.02 (–0.65 to 4.68)	.138	–3.04 (–9.16 to 3.09)	.33
Medial meniscal treatment				
None	—	—	—	—
Excision	1.21 (–0.91 to 3.33)	.262	2.95 (–1.9 to 7.8)	.233
Repair	0.94 (–1.08 to 2.96)	.361	–0.88 (–5.52 to 3.76)	.709
Lateral meniscal treatment				
None	—	—	—	—
Excision	0.96 (–0.71 to 2.62)	.259	4.41 (0.59 to 8.24)	**.024**
Repair	–0.21 (–3.48 to 3.06)	.899	–3.16 (–10.67 to 4.35)	.409
Surgery type				
Primary	—	—	—	—
Revision	–5.34 (–8.63 to –2.05)	**.002**	–9.82 (–17.38 to –2.26)	**.011**
No. of people in household	–0.02 (–0.51 to 0.47)	.932	–0.24 (–1.37 to 0.89)	.672
Baseline score	0.22 (0.17 to 0.27)	**<.001**	0.25 (0.17 to 0.34)	**<.001**
Baseline Marx score	0.03 (–0.15 to 0.21)	.71	0.19 (–0.23 to 0.6)	.373
Education	–0.01 (–0.66 to 0.65)	.979	–2.2 (–3.7 to –0.7)	**.004**
Employment status				
Unemployed	—	—	—	—
Part-time	2.2 (–0.41 to 4.82)	.099	1.26 (−4.77 to 7.28)	.682
Full-time	1.34 (–1.46 to 4.15)	.347	2.09 (−4.37 to 8.54)	.525
Student				
No	—	—	—	—
Yes	1.06 (–1.86 to 3.97)	.477	3.56 (−3.15 to 10.26)	.298
Disabled				
No	—	—	—	—
Yes	–0.92 (–5.77 to 3.93)	.708	−8.22 (−19.3 to 2.85)	.145
Interaction (age, education)	0.02 (–0.01 to 0.04)	.157	0.08 (0.03 to 0.14)	**.003**
SES index	0.36 (0.15 to 0.57)	**.001**	0.5 (0.02 to 0.98)	**.04**

[a]Dashes indicate reference variable. Bolded *P* values indicate statistical significance compared with reference variable. ADL, Activities of Daily Living; BMI, body mass index; BTB, bone–patellar tendon–bone; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; QoL, Quality of Life; SES, socioeconomic status.

"Clinical" indicates the model with only clinical variables, "A" indicates the additional variables that are traditionally used to account for SES (years of education, employment status, student status, disability status, interaction of age and education), and "B" indicates the SES index variable. For 4 of the outcomes (KOOS Activities of Daily Living [ADL], Knee-Related Quality of Life, and Pain subscales and the Marx scale), the model performed significantly better with the A variables. When the B variable was added to these models, the model improved in each case. For the

TABLE 6
Coefficients and *P* Values for the Best Model for KOOS Pain, Sports and Recreation, and Symptoms Outcomes[a]

	KOOS Pain		KOOS Sports&Rec		KOOS Symptoms	
Variable	Effect (95% CI)	*P*	Effect (95% CI)	*P*	Effect (95% CI)	*P*
Age	0.02 (–0.1 to 0.14)	.745	–0.13 (–0.34 to 0.08)	.24	0.03 (–0.11 to 0.18)	.654
Sex						
Female	—	—	—	—	—	—
Male	–1.38 (–3.41 to 0.65)	.183	–0.86 (–4.31 to 2.58)	.623	–0.15 (–2.58 to 2.28)	.904
Race						
White	—	—	—	—	—	—
Black	1.73 (–1.88 to 5.34)	.347	–0.03 (–6.05 to 5.98)	.991	1.7 (–2.61 to 6.01)	.439
Other	–1.3 (–6.16 to 3.56)	.6	–1.34 (–9.41 to 6.73)	.744	–2.93 (–8.74 to 2.87)	.321
BMI	–0.13 (–0.37 to 0.1)	.27	–0.32 (–0.72 to 0.07)	.111	–0.31 (–0.59 to –0.03)	**.029**
Smoking status						
Never	—	—	—	—	—	—
Quit	–1.28 (–4.71 to 2.15)	.463	–2.43 (–8.27 to 3.4)	.413	–3.8 (–7.88 to 0.29)	.069
Current	–5.02 (–8.52 to –1.52)	**.005**	–12.03 (–17.81 to –6.25)	**<.001**	–6.57 (–10.74 to –2.39)	**.002**
Competition level						
None	—	—	—	—	—	—
Recreational	1.48 (–3.8 to 6.76)	.583	–0.84 (–9.58 to 7.9)	.85	–1.23 (–7.5 to 5.03)	.699
Competitive	1.74 (–4.33 to 7.8)	.574	–1.55 (–11.64 to 8.53)	.763	–3.22 (–10.44 to 4)	.381
Graft						
BTB autograft	—	—	—	—	—	—
Hamstring autograft	0.56 (–1.87 to 2.98)	.651	1.84 (–2.27 to 5.94)	.379	0.49 (–2.4 to 3.39)	.738
Allograft	0.2 (–3.28 to 3.69)	.908	2.34 (–3.43 to 8.11)	.426	–0.67 (–4.83 to 3.49)	.753
Medial meniscal treatment						
None	—	—	—	—	—	—
Excision	2.56 (–0.22 to 5.35)	.071	1.33 (–3.36 to 6.01)	.579	0.84 (–2.48 to 4.17)	.618
Repair	0.48 (–2.17 to 3.12)	.724	1.08 (–3.44 to 5.59)	.639	–0.77 (–3.93 to 2.39)	.632
Lateral meniscal treatment						
None	—	—	—	—	—	—
Excision	0.66 (–1.53 to 2.86)	.553	2.79 (–0.91 to 6.48)	.139	1.13 (–1.48 to 3.74)	.396
Repair	–0.86 (–5.17 to 3.44)	.694	–1.43 (–8.55 to 5.7)	.694	0.95 (–4.18 to 6.08)	.715
Surgery type						
Primary	—	—	—	—	—	—
Revision	–6.82 (–11.13 to –2.52)	**.002**	–6.46 (–13.59 to 0.68)	.076	–2.55 (–7.7 to 2.6)	.331
No. of people in household	–0.1 (–0.72 to 0.52)	.747	–0.08 (–1.12 to 0.95)	.875	–0.02 (–0.76 to 0.72)	.955
Baseline score	0.29 (0.23 to 0.35)	**<.001**	0.16 (0.1 to 0.22)	**<.001**	0.26 (0.2 to 0.33)	**<.001**
Baseline Marx score	0.17 (–0.07 to 0.41)	.158	0.11 (–0.29 to 0.51)	.588	0.06 (–0.22 to 0.34)	.663
Education						
Employment status						
Unemployed						
Part-time						
Full-time						
Student						
No						
Yes						
Disabled						
No						
Yes						
Interaction (age, education)						
SES index	0.35 (0.08 to 0.62)	**.011**	0.59 (0.14 to 1.05)	**.011**	0.31 (–0.01 to 0.64)	.058

[a]Dashes indicate reference variable. Bolded *P* values indicate statistical significance compared with reference variable. Gray shading indicates parameters that were not included in the model for that column. BMI, body mass index; BTB, bone–patellar tendon–bone; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; SES, socioeconomic status; Sports&Rec, Sports and Recreation.

other 3 outcome measures (KOOS Sports and Recreation and Symptoms subscales and the IKDC), addition of the B variable to the clinical model significantly improved the model in each case. Of note, the SES index (B variable) was always positive, indicating that higher SES index was associated with better PRO scores.

TABLE 7
Coefficients and *P* Values for the Best Model for Marx and IKDC Outcomes[a]

	Marx		IKDC	
Variable	Effect (95% CI)	*P*	Effect (95% CI)	*P*
Age	–0.16 (–0.34 to 0.02)	.074	–0.04 (–0.19 to 0.11)	.606
Sex				
Female	—	—	—	—
Male	1.13 (0.4 to 1.86)	**.003**	1.32 (–1.13 to 3.76)	.29
Race				
White	—	—	—	—
Black	–0.81 (–2.09 to 0.48)	.219	2.25 (–2.04 to 6.55)	.304
Other	0.4 (–1.34 to 2.14)	.655	–0.44 (–6.23 to 5.34)	.88
BMI	–0.07 (–0.15 to 0.01)	.105	–0.34 (–0.62 to –0.05)	**.02**
Smoking status				
Never	—	—	—	—
Quit	–1.66 (–2.89 to –0.43)	**.008**	–2.42 (–6.66 to 1.82)	.262
Current	–1.38 (–2.65 to –0.12)	**.032**	–6.91 (–11.05 to –2.76)	**.001**
Competition level				
None	—	—	—	—
Recreational	–0.4 (–2.39 to 1.6)	.697	1.51 (–4.86 to 7.88)	.641
Competitive	0.72 (–1.52 to 2.96)	.529	1.93 (–5.37 to 9.24)	.604
Graft				
BTB autograft	—	—	—	—
Hamstring autograft	–0.55 (–1.43 to 0.33)	.223	1.79 (–1.12 to 4.69)	.227
Allograft	–1.89 (–3.14 to –0.64)	**.003**	1.21 (–2.95 to 5.37)	.569
Medial meniscal treatment				
None	—	—	—	—
Excision	0.16 (–0.83 to 1.16)	.748	1.49 (–1.85 to 4.83)	.38
Repair	–0.55 (–1.5 to 0.39)	.252	1.34 (–1.83 to 4.52)	.406
Lateral meniscal treatment				
None	—	—	—	—
Excision	0.81 (0.03 to 1.59)	**.042**	2.14 (–0.49 to 4.77)	.111
Repair	0.33 (–1.23 to 1.88)	.679	–0.31 (–5.42 to 4.8)	.904
Surgery type				
Primary	—	—	—	—
Revision	–1.26 (–2.8 to 0.29)	.111	–8.8 (–13.92 to –3.68)	**.001**
No. of people in household	0.01 (–0.22 to 0.24)	.926	0.05 (–0.7 to 0.79)	.903
Baseline score			0.33 (0.26 to 0.4)	**<.001**
Baseline Marx score	0.35 (0.27 to 0.44)	**<.001**	0.28 (0 to 0.56)	.053
Education	–0.34 (–0.65 to –0.03)	**.029**		
Employment status				
Unemployed	—	—		
Part-time	0.67 (–0.56 to 1.91)	.283		
Full-time	0.38 (–0.95 to 1.71)	.577		
Student				
No	—	—		
Yes	1.01 (–0.36 to 2.39)	.148		
Disabled				
No	—	—		
Yes	–3.33 (–5.64 to –1.03)	**.005**		
Interaction (age, education)	0.01 (0 to 0.02)	.071		
SES index	0.13 (0.04 to 0.23)	**.007**	0.51 (0.19 to 0.84)	**.002**

[a]Dashes indicate reference variable. Bolded *P* values indicate statistical significance compared with reference variable. Gray shading indicates parameters that were not included in the model for that column. BMI, body mass index; BTB, bone–patellar tendon–bone; IKDC, International Knee Documentation Committee; Marx, Marx activity rating scale; SES, socioeconomic status.

Tables 5 through 7 show coefficients for socioeconomic variables retained in the final models. Coefficients for the A variables are not reported if the addition of these variables did not improve the model. Of note, in the models that included the A variables but not the SES index, the interaction term between age and education was significant ($P < .04$) for the Marx, the

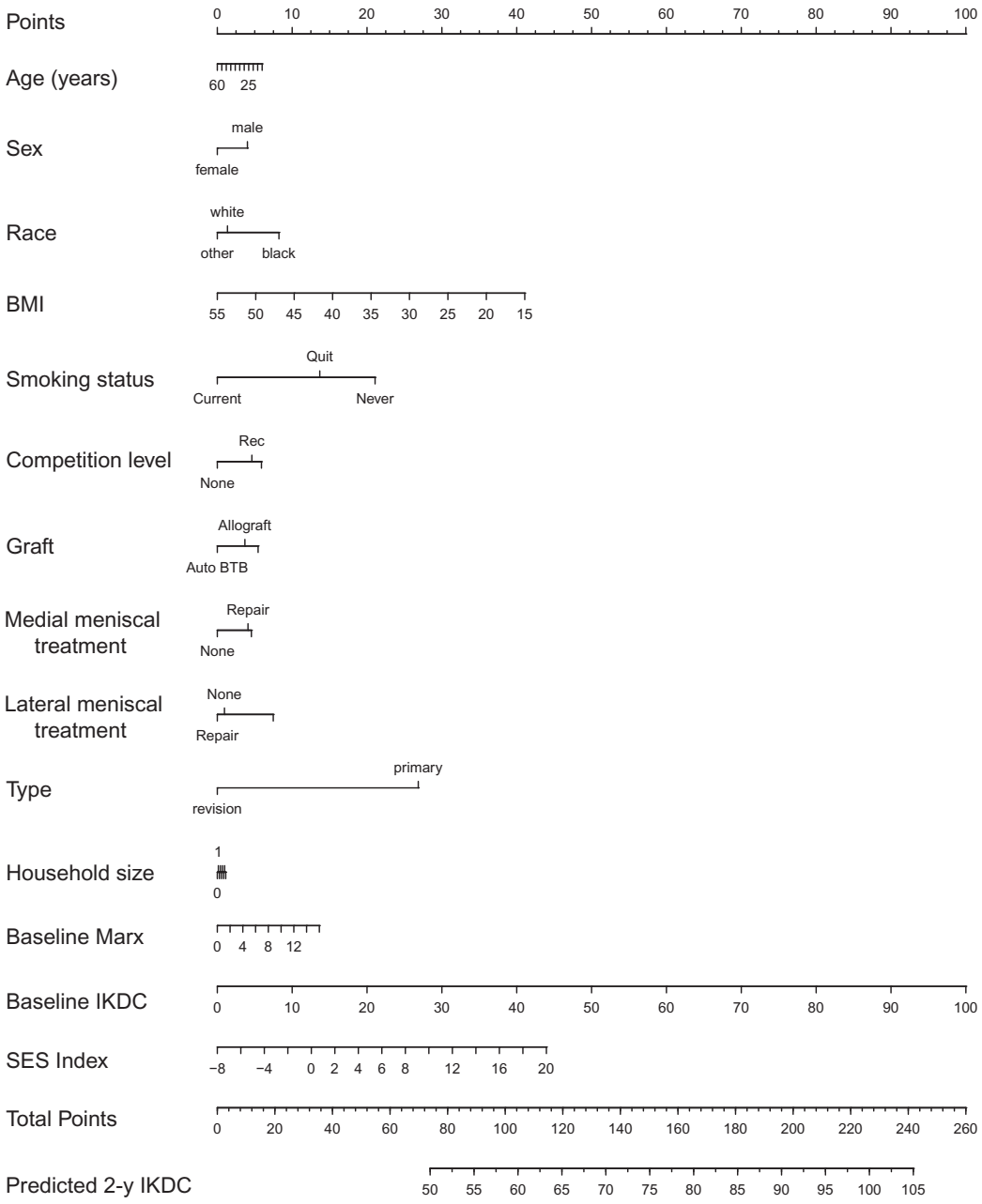

Figure 2. Nomogram for International Knee Documentation Committee (IKDC) score. BMI, body mass index; BTB, bone–patellar tendon–bone; SES, socioeconomic status.

IKDC, and all of the KOOS subscales except ADL. For more detailed information, see Appendix Tables A1 through A4. A representative nomogram for predicting IKDC score is presented in Figure 2 to give a visual representation of the relative contribution of each baseline factor to 2-year outcome. The remaining nomograms can be found in Appendix Figures A1 through A6.

Figure 3 presents boxplots that show the difference in distribution and mean for each PRO score between the lowest 10% and highest 10% of SES index values. A broader distribution of values is seen for patients with the lowest SES index, and the mean difference exceeds the minimal clinically important difference for the majority of PROs.

DISCUSSION

Our analysis demonstrates that socioeconomic variables are significant predictors of PRO after ACL reconstruction and that the interaction between age and education level should be evaluated in this patient population because of the large proportion of students who undergo ACL surgery. Our findings also show that neighborhood factors are important

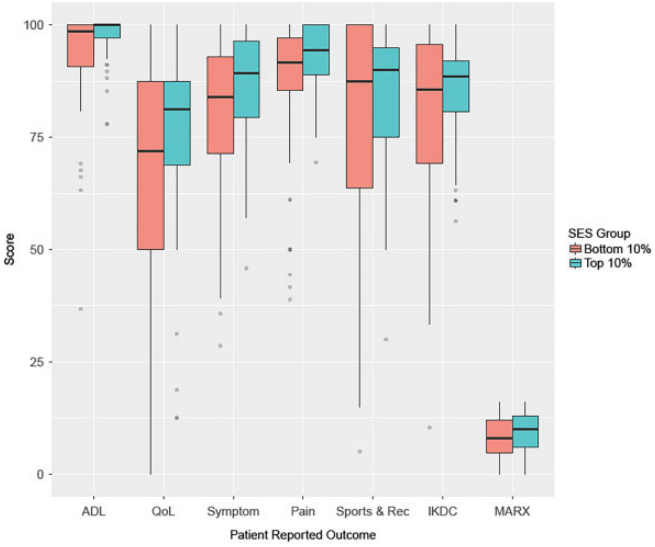

Figure 3. Boxplots depicting the distribution difference between the bottom 10% and top 10% of the SES group, stratified by 2-year patient-reported outcomes (KOOS subscales, IKDC, Marx). ADL, Activities of Daily Living; IKDC, International Knee Documentation Committee; Marx, Marx activity rating scale; QoL, Knee-related Quality of Life; SES, socioeconomic status; Sports&Rec, Sports and Recreation.

predictors of outcome, in addition to the patient factors that are traditionally captured in clinical outcomes research. Furthermore, greater variation was seen in the outcomes of patients with the lowest SES. This suggests that improving access to care in neighborhoods with lower SES may provide an opportunity to lessen this variability and improve patient outcomes and that, when possible, future studies of outcomes after ACL reconstruction should include a measure of neighborhood SES. To our knowledge, this is the first study to evaluate the impact of SES on PRO after ACL reconstruction using both individual and neighborhood measures.

Multiple studies have evaluated the relationship between SES and orthopaedic outcomes. In a nationwide study of 25,354 elderly patients with hip fracture conducted in Denmark, patients with higher education levels and higher family incomes had lower rates of readmission and lower 30-day mortality rates.[13] In a Swedish study that examined the relationships between education level, household income, and likelihood of undergoing surgical treatment for cruciate ligament injury, the investigators found that patients with higher family income and/or education level were more likely to undergo surgical treatment.[16]

Insurance status has been used as a surrogate for SES to evaluate the relationship between SES and outcome after orthopaedic procedures. For example, Sabesan and colleagues[17] showed that patients with Medicaid had a higher risk of complications and higher total charges after treatment of proximal humeral fractures. We did not prospectively record insurance status for our patients and could not reliably obtain this information retrospectively, so our analysis did not account for this variable.

Previous studies from our cohort have shown that nonwhite race predicts worse outcome after ACL reconstruction.[6,10] However, the relationship between race and outcome is confounded by SES. For example, in a systematic review of studies that reported revision rates after total knee replacement, a significant relationship was seen between race and outcome only in the study that did not adjust for insurance payer status.[2] Likewise, in the current study, race was not an independent predictor of outcome after the addition of socioeconomic variables.

Several potentially modifiable risk factors may be associated with differences in neighborhood SES but were not captured or analyzed in our current study. These include delays in accessing care (including office visits, diagnostic testing, surgery, and physical therapy) due to insurance access, transportation, or job status; differences in comorbidities between people in different neighborhoods; differences in sports and exercise participation; and differences in overall activity level. This study was performed prior to the Affordable Care Act, and any effect of this act on improving access to health care is unknown. These factors would make excellent topics for future study.

CONCLUSION

This is the first study to examine the impact of SES, using both individual and neighborhood measures, on PRO following ACL reconstruction surgery. We showed that neighborhood SES is associated with worse PRO after ACL reconstruction, with greater variability in outcome in the patients at the lowest end of the socioeconomic spectrum. In addition, we found that the effect of education on outcome varies with patient age in this population.

Future studies in the ACL reconstruction population should account for neighborhood SES when adjusting for confounding factors and should attempt to identify the modifiable risk factors for worse outcome in patients from low SES neighborhoods. That way, these patients can potentially be offered special interventions to improve their outcomes.

AUTHORS

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APPENDIX

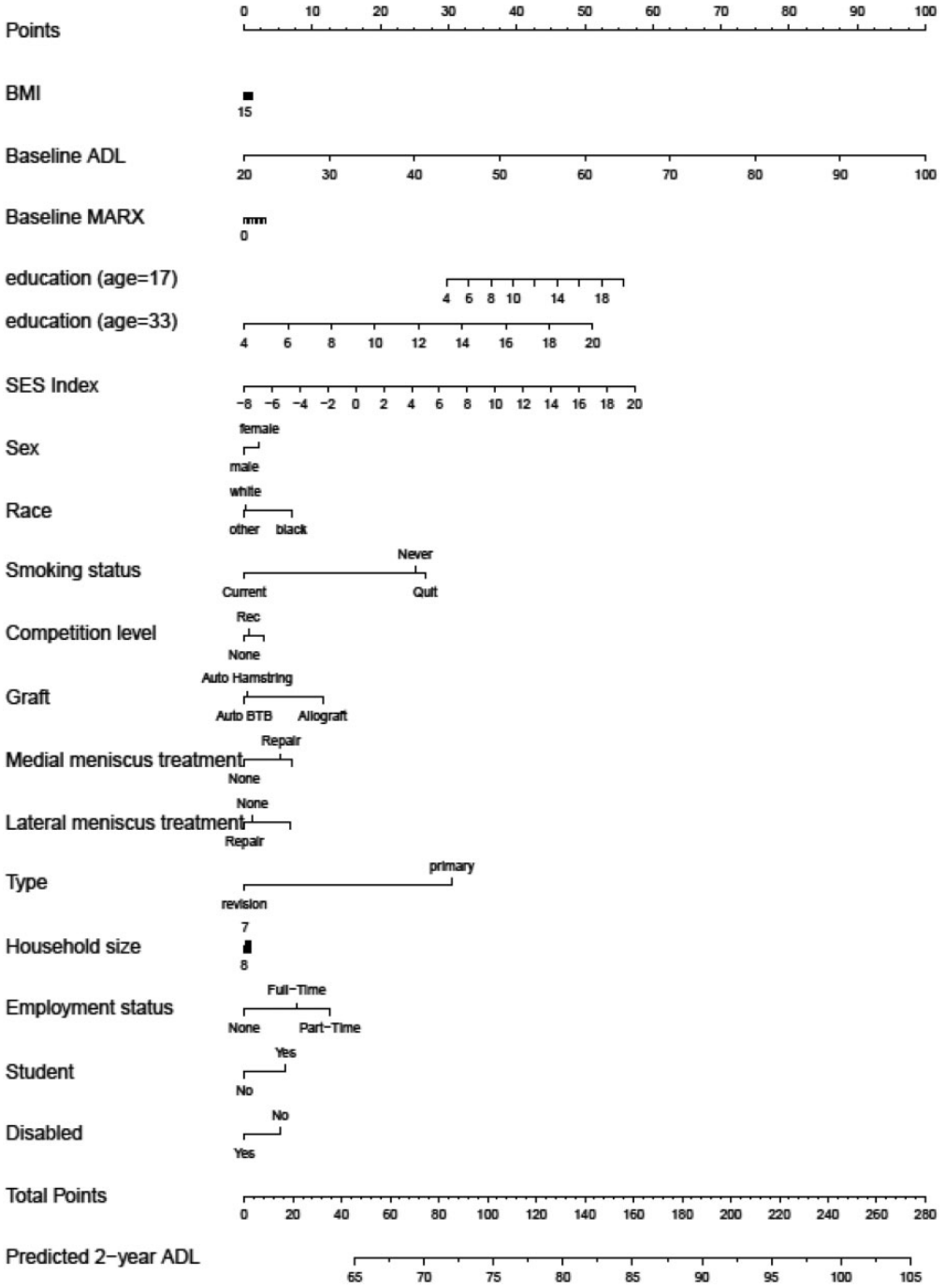

Figure A1. Nomogram for KOOS Activities of Daily Living (ADL). BMI, body mass index; BTB, bone–patellar tendon–bone; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; SES, socioeconomic status.

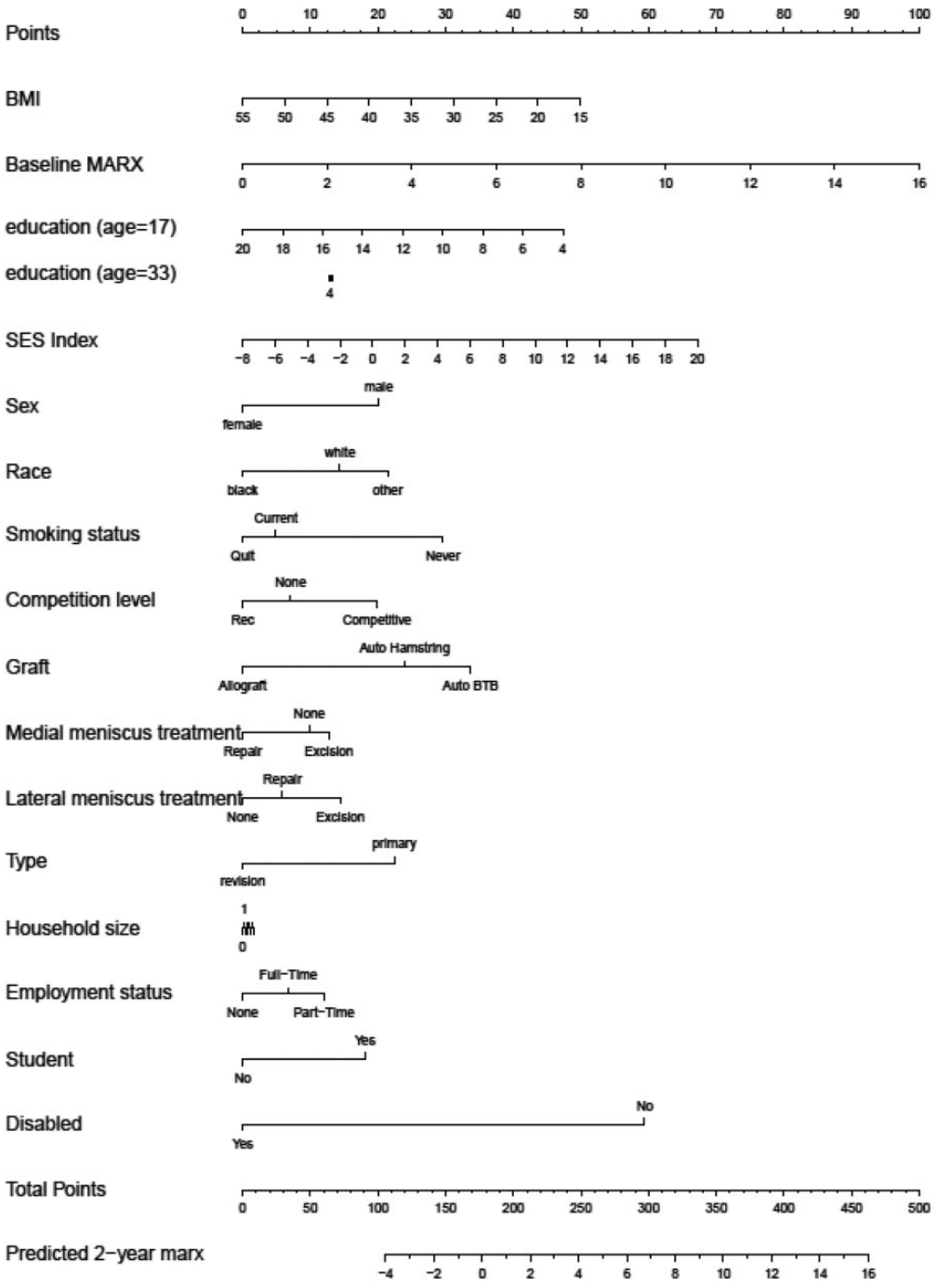

Figure A2. Nomogram for Marx activity rating scale (Marx). BMI, body mass index; BTB, bone–patellar tendon–bone; SES, socioeconomic status.

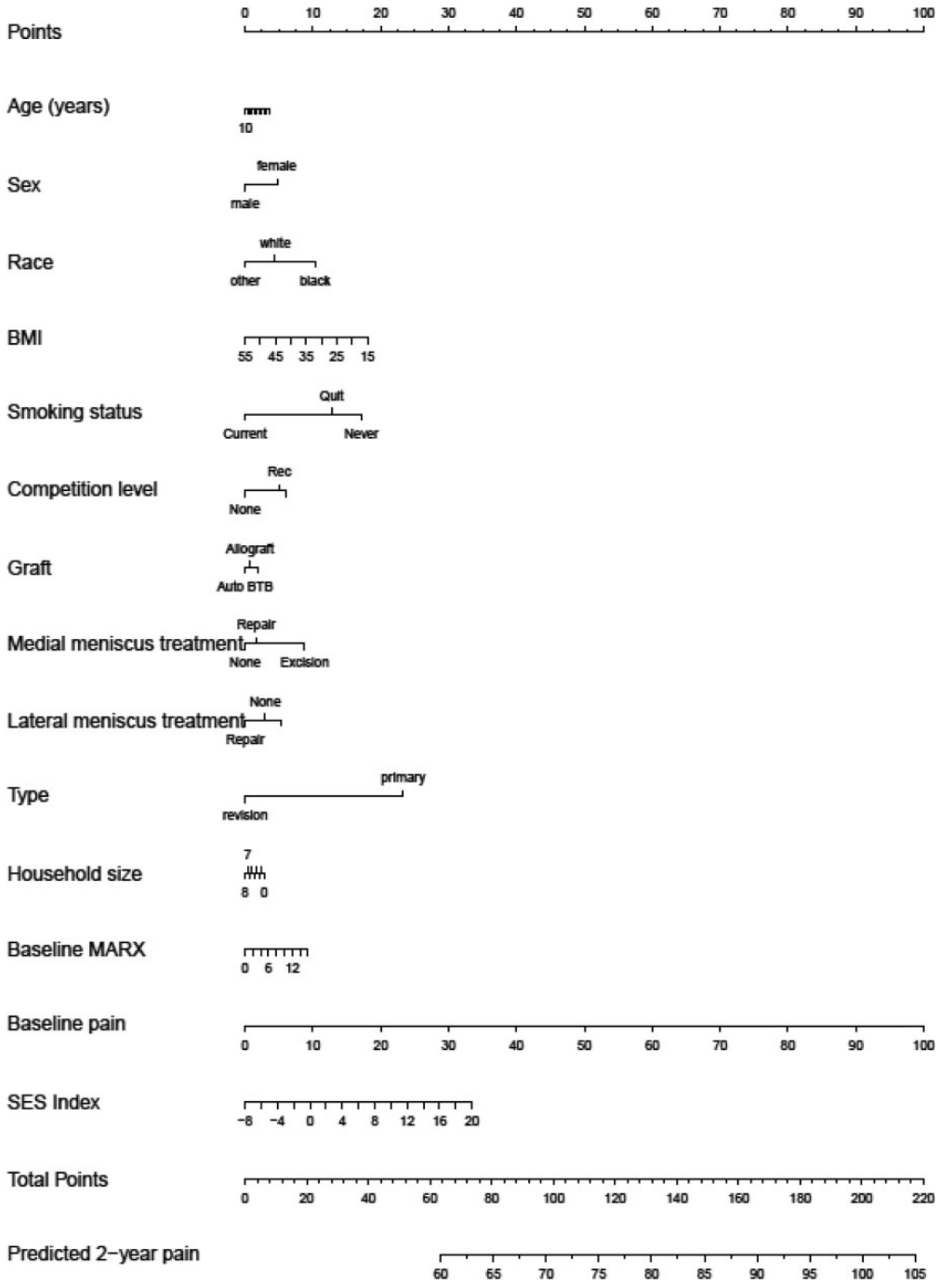

Figure A3. Nomogram for KOOS Pain. BMI, body mass index; BTB, bone–patellar tendon–bone; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; SES, socioeconomic status.

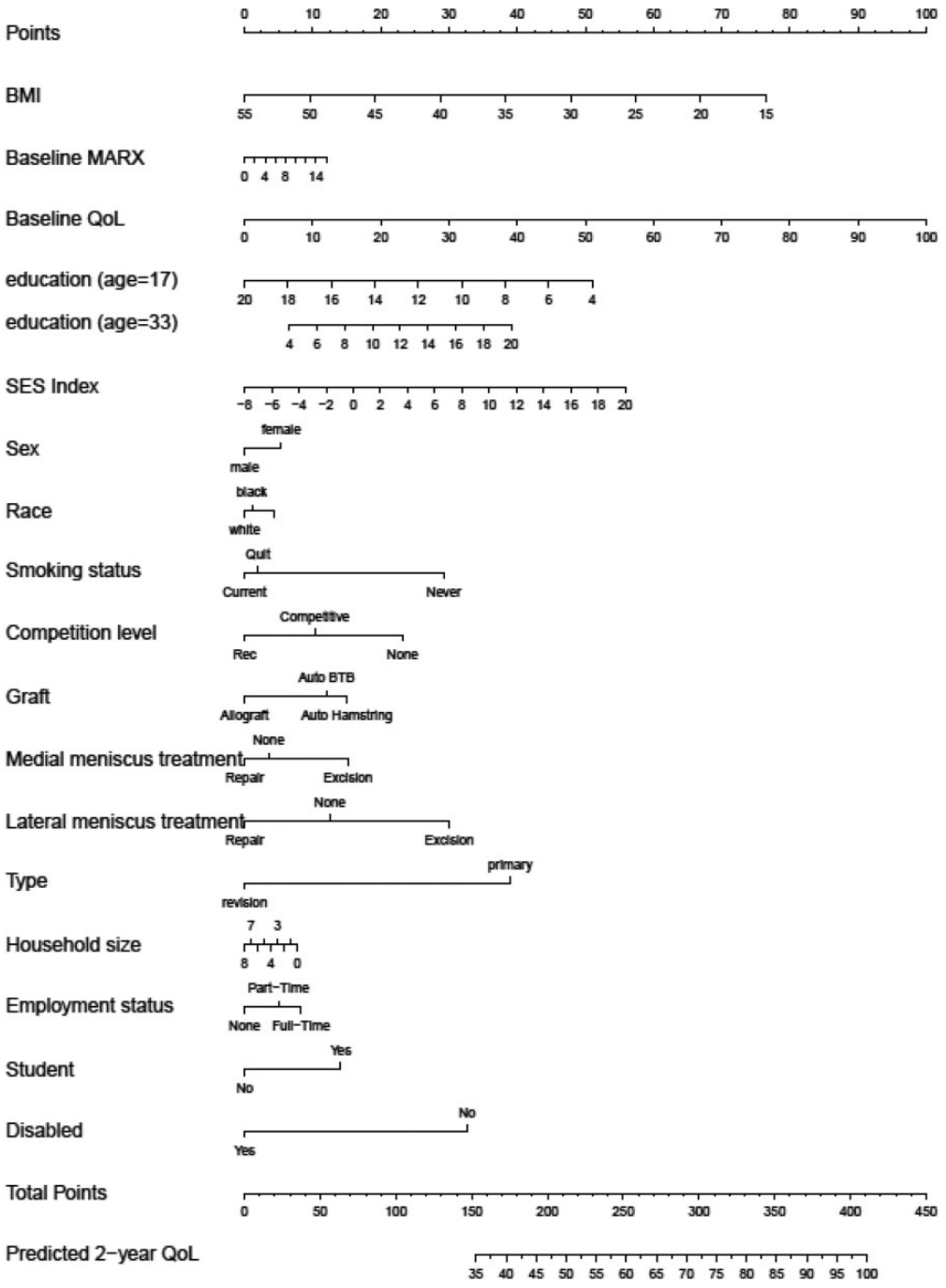

Figure A4. Nomogram for KOOS Knee-related Quality of Life (QoL). BMI, body mass index; BTB, bone–patellar tendon–bone; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; SES, socioeconomic status.

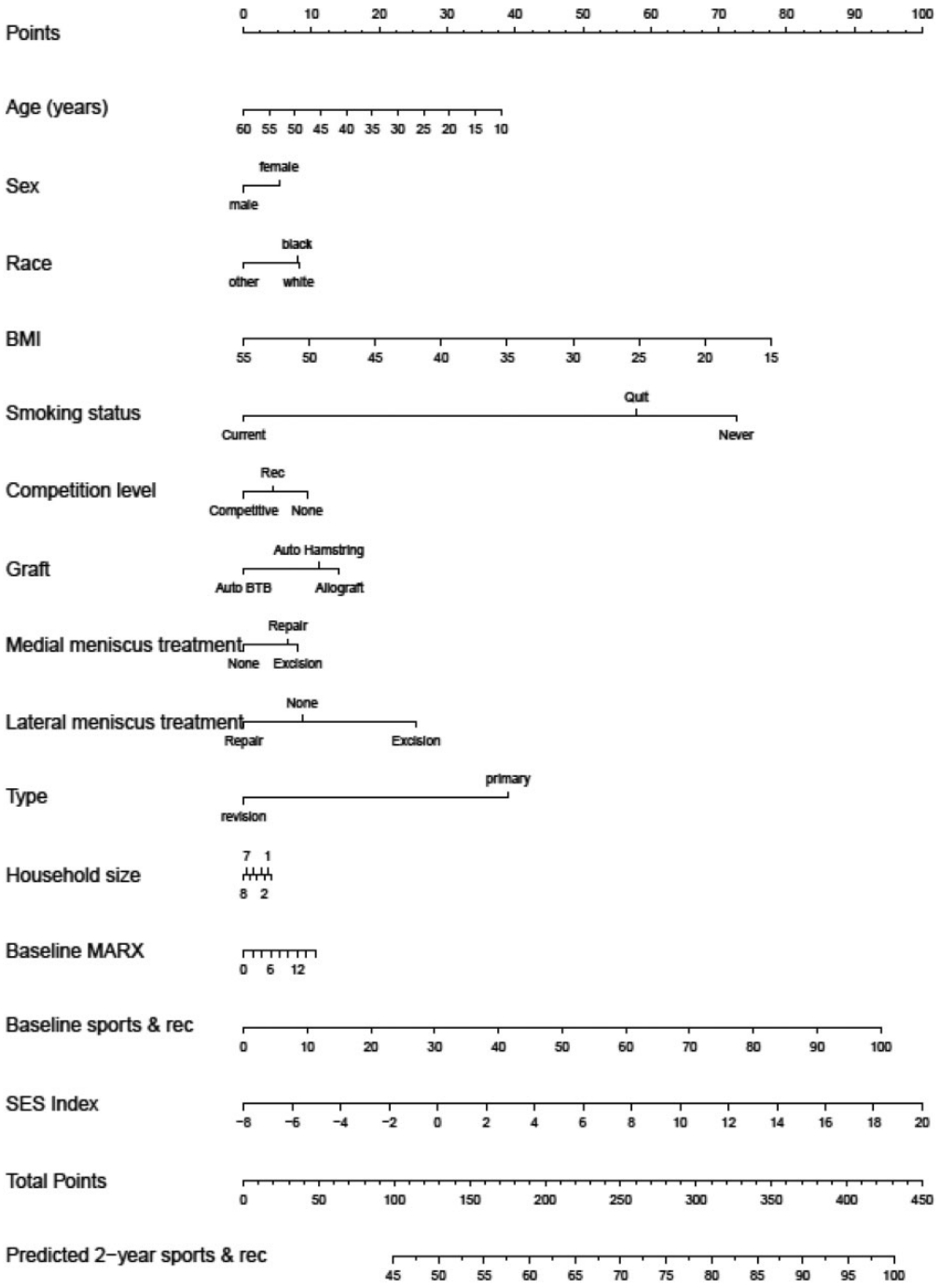

Figure A5. Nomogram for KOOS Sports and Recreation. BMI, body mass index; BTB, bone–patellar tendon–bone; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; SES, socioeconomic status; Sports&Rec, Sports and Recreation.

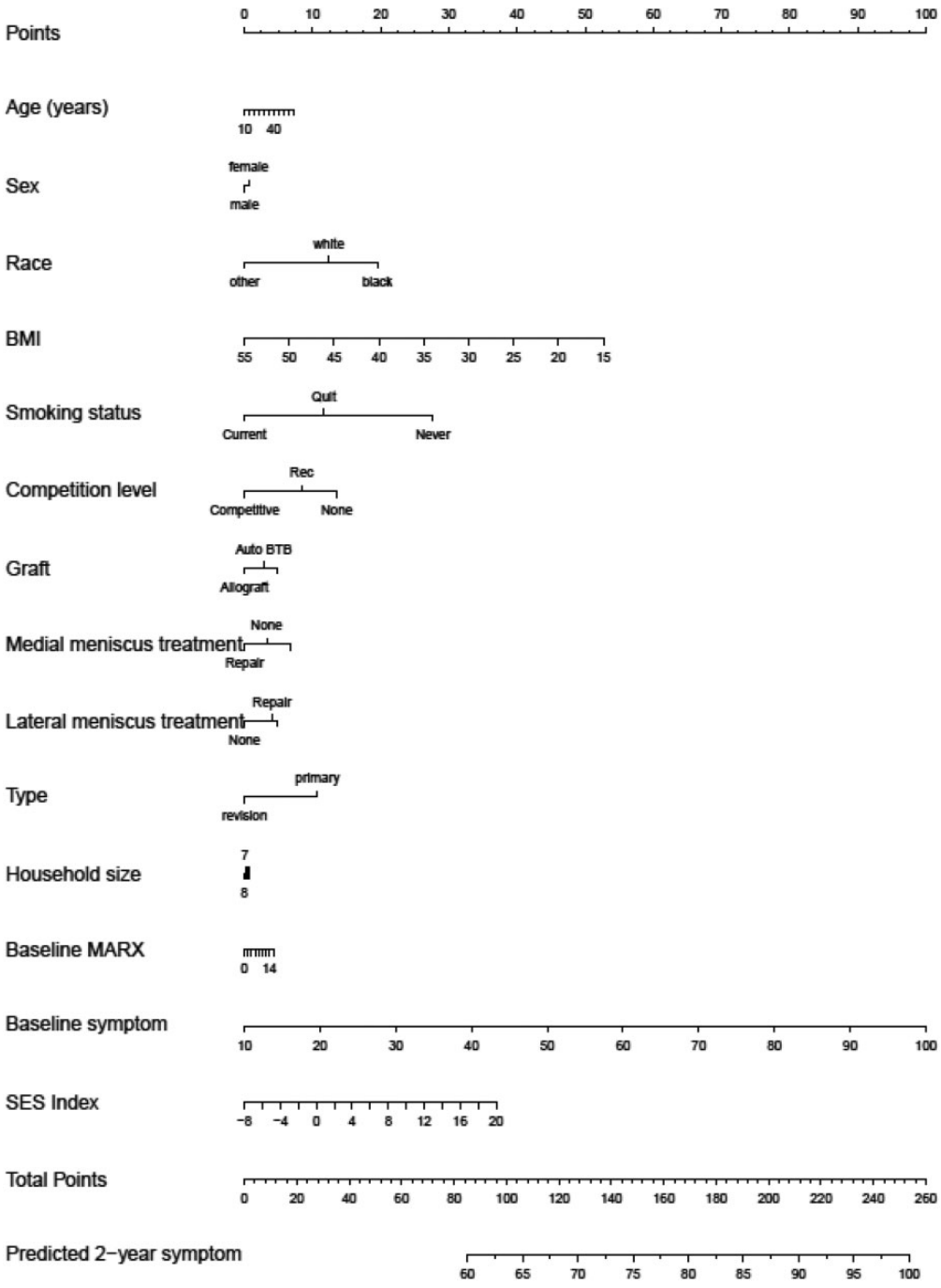

Figure A6. Nomogram for KOOS Symptoms. BMI, body mass index; BTB, bone–patellar tendon–bone; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; SES, socioeconomic status.

TABLE A1
Coefficients and *P* Values for the Clinical Model for KOOS ADL, QoL, and Pain Outcomes[a]

	ADL		QoL		Pain	
Variable	Effect (95% CI)	*P*	Effect (95% CI)	*P*	Effect (95% CI)	*P*
Age, y	–0.03 (–0.13 to 0.06)	.5	0.09 (–0.12 to 0.31)	.393	0.05 (–0.07 to 0.17)	.428
Sex						
Female	—	—	—	—	—	—
Male	–0.46 (–2.03 to 1.11)	.564	–1.81 (–5.39 to 1.76)	.32	–1.47 (–3.5 to 0.57)	.158
Race						
White	—	—	—	—	—	—
Black	0.13 (–2.61 to 2.88)	.924	–1.46 (–7.73 to 4.82)	.648	0.95 (–2.63 to 4.52)	.603
Other	–0.03 (–3.76 to 3.7)	.988	0.22 (–8.3 to 8.75)	.959	–1.9 (–6.77 to 2.96)	.443
BMI	–0.04 (–0.22 to 0.14)	.651	–0.62 (–1.03 to –0.22)	.003	–0.18 (–0.41 to 0.05)	.132
Smoking status						
Never	—	—	—	—	—	—
Quit	0.45 (–2.21 to 3.11)	.738	–6.92 (–12.94 to –0.89)	.025	–1.08 (–4.52 to 2.36)	.538
Current	–5.66 (–8.34 to –2.98)	<.001	–10.6 (–16.68 to –4.51)	<.001	–5.34 (–8.85 to –1.83)	.003
Competition level						
None	—	—	—	—	—	—
Recreational	2.12 (–1.97 to 6.22)	.309	–3.15 (–12.37 to 6.06)	.502	1.78 (–3.52 to 7.08)	.509
Competitive	2.43 (–2.27 to 7.12)	.31	–0.42 (–11.04 to 10.19)	.938	2.18 (–3.91 to 8.26)	.482
Graft						
BTB autograft	—	—	—	—	—	—
Hamstring autograft	0.56 (–1.3 to 2.42)	.553	1.73 (–2.54 to 5.99)	.426	0.96 (–1.46 to 3.37)	.438
Allograft	1.76 (–0.92 to 4.44)	.197	–2.52 (–8.64 to 3.6)	.419	–0.14 (–3.63 to 3.35)	.939
Medial meniscal treatment						
None	—	—	—	—	—	—
Excision	0.92 (–1.23 to 3.08)	.401	2.55 (–2.34 to 7.45)	.306	2.43 (–0.36 to 5.22)	.088
Repair	0.78 (–1.26 to 2.82)	.453	–0.85 (–5.51 to 3.82)	.722	0.24 (–2.41 to 2.89)	.86
Lateral meniscal treatment						
None	—	—	—	—	—	—
Excision	0.85 (–0.84 to 2.54)	.324	4.65 (0.79 to 8.51)	.018	0.57 (–1.64 to 2.77)	.614
Repair	–0.08 (–3.39 to 3.23)	.962	–2.09 (–9.66 to 5.47)	.587	–0.58 (–4.9 to 3.73)	.791
Surgery type						
Primary	—	—	—	—	—	—
Revision	–4.59 (–7.89 to –1.29)	.006	–10.29 (–17.82 to –2.76)	.007	–6.18 (–10.47 to –1.88)	.005
No, of people in household	–0.02 (–0.49 to 0.46)	.941	0.22 (–0.87 to 1.31)	.69	0 (–0.62 to 0.61)	.988
Baseline score	0.24 (0.19 to 0.29)	<.001	0.27 (0.19 to 0.36)	<.001	0.3 (0.24 to 0.36)	<.001
Baseline Marx	0.04 (–0.15 to 0.22)	.698	0.21 (–0.21 to 0.63)	.322	0.17 (–0.07 to 0.41)	.161

[a]Dashes indicate reference variable. ADL, Activities of Daily Living; BMI, body mass index; BTB, bone–patellar tendon–bone; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; QoL, Quality of Life.

TABLE A2
Coefficients and *P* Values for the Clinical Model for KOOS Sports&Rec, Symptoms, Marx, and IKDC Outcomes[a]

	Sports&Rec		Symptom		Marx		IKDC	
Variable	Effect (95% CI)	*P*	Effect (95% CI)	*P*	Effect (95% CI)	*P*	Effect (95% CI)	*P*
Age	–0.08 (–0.29 to 0.12)	.428	0.06 (–0.09 to 0.21)	.414	–0.04 (–0.09 to 0)	.049	0 (–0.15 to 0.15)	.989
Sex								
Female	—	—	—	—	—	—	—	—
Male	–0.89 (–4.35 to 2.57)	.613	–0.25 (–2.68 to 2.19)	.842	0.96 (0.23 to 1.7)	.011	1.16 (–1.3 to 3.62)	.354
Race								
White	—	—	—	—	—	—	—	—
Black	–1.38 (–7.34 to 4.57)	.648	0.99 (–3.26 to 5.25)	.646	–1.2 (–2.49 to 0.09)	.069	1.07 (–3.2 to 5.33)	.623
Other	–2.16 (–10.24 to 5.92)	.6	–3.46 (–9.25 to 2.33)	.241	0.13 (–1.62 to 1.89)	.881	–1.3 (–7.1 to 4.5)	.66
BMI	–0.4 (–0.79 to –0.01)	.046	–0.35 (–0.63 to –0.08)	.013	–0.11 (–0.19 to –0.02)	.014	–0.4 (–0.69 to –0.12)	.005
Smoking status								
Never	—	—	—	—	—	—	—	—
Quit	–2.16 (–8.02 to 3.7)	.469	–3.64 (–7.74 to 0.45)	.081	–1.67 (–2.91 to –0.42)	.009	–2.1 (–6.36 to 2.17)	.334
Current	–12.68 (–18.46 to –6.9)	<.001	–6.95 (–11.11 to –2.78)	.001	–2.09 (–3.34 to –0.85)	.001	–7.4 (–11.57 to –3.24)	<.001
Competition level								
None	—	—	—	—	—	—	—	—
Recreational	–0.41 (–9.18 to 8.37)	.927	–0.93 (–7.2 to 5.34)	.771	–0.08 (–2.06 to 1.89)	.933	1.96 (–4.45 to 8.38)	.548
Competitive	–1.02 (–11.15 to 9.1)	.843	–2.77 (–9.99 to 4.45)	.451	1.23 (–1.03 to 3.48)	.286	2.55 (–4.79 to 9.9)	.495
Graft								
BTB autograft	—	—	—	—	—	—	—	—
Hamstring autograft	2.39 (–1.72 to 6.49)	.254	0.86 (–2.02 to 3.73)	.56	–0.38 (–1.25 to 0.5)	.398	2.34 (–0.56 to 5.25)	.113
Allograft	1.73 (–4.04 to 7.51)	.556	–0.98 (–5.13 to 3.18)	.644	–1.8 (–3.06 to –0.54)	.005	0.73 (–3.45 to 4.91)	.732
Medial meniscal treatment								
None	—	—	—	—	—	—	—	—
Excision	1.05 (–3.66 to 5.76)	.661	0.73 (–2.6 to 4.06)	.666	0.07 (–0.94 to 1.08)	.887	1.28 (–2.08 to 4.64)	.453
Repair	0.5 (–4.01 to 5.02)	.827	–0.97 (–4.13 to 2.19)	.547	–0.59 (–1.55 to 0.37)	.228	1 (–2.19 to 4.19)	.538
Lateral meniscal treatment								
None	—	—	—	—	—	—	—	—
Excision	2.68 (–1.04 to 6.39)	.157	1.06 (–1.56 to 3.68)	.426	0.86 (0.06 to 1.65)	.035	2.01 (–0.64 to 4.66)	.136
Repair	–1 (–8.15 to 6.15)	.784	1.25 (–3.88 to 6.38)	.634	0.54 (–1.04 to 2.11)	.503	0.12 (–5.02 to 5.26)	.962
Surgery type								
Primary	—	—	—	—	—	—	—	—
Revision	–5.24 (–12.35 to 1.87)	.148	–1.95 (–7.07 to 3.18)	.455	–1.42 (–2.96 to 0.13)	.073	–7.85 (–12.98 to –2.73)	.003
No. of people in household	0.08 (–0.96 to 1.12)	.879	0.07 (–0.67 to 0.81)	.854	0.13 (–0.1 to 0.35)	.266	0.19 (–0.55 to 0.94)	.611
Baseline score	0.16 (0.1 to 0.22)	<.001	0.27 (0.2 to 0.33)	<.001			0.34 (0.26 to 0.41)	<.001
Baseline Marx score	0.11 (–0.29 to 0.51)	.58	0.06 (–0.22 to 0.34)	.676	0.35 (0.26 to 0.43)	<.001	0.28 (–0.01 to 0.56)	.055

[a]Dashes indicate reference variable. Gray shading indicates parameters that were not included in the model for that column. BMI, body mass index; BTB, bone–patellar tendon–bone; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale.

TABLE A3
Coefficients and *P* Values for the Clinical + A Model for KOOS ADL, QoL, and Pain Outcomes[a]

	ADL		QoL		Pain	
Variable	Effect (95% CI)	*P*	Effect (95% CI)	*P*	Effect (95% CI)	*P*
Age	–0.44 (–0.81 to –0.06)	.023	–1.09 (–1.95 to –0.23)	.013	–0.6 (–1.09 to –0.1)	.018
Sex						
Female	—	—	—	—	—	—
Male	–0.46 (–2.03 to 1.11)	.564	–1.44 (–5.01 to 2.14)	.431	–1.47 (–3.52 to 0.58)	.158
Race						
White	—	—	—	—	—	—
Black	0.42 (–2.31 to 3.14)	.764	–0.81 (–7.05 to 5.44)	.8	1.31 (–2.26 to 4.87)	.472
Other	–0.69 (–4.4 to 3.03)	.716	0.21 (–8.28 to 8.71)	.96	–2.38 (–7.25 to 2.48)	.337
BMI	–0.04 (–0.22 to 0.14)	.691	–0.54 (–0.95 to –0.13)	.01	–0.17 (–0.41 to 0.06)	.153
Smoking status						
Never	—	—	—	—	—	—
Quit	0.47 (–2.18 to 3.12)	.73	–6.57 (–12.58 to –0.57)	.032	–1.02 (–4.46 to 2.42)	.561
Current	–4.56 (–7.29 to –1.83)	.001	–7.59 (–13.81 to –1.37)	.017	–3.99 (–7.58 to –0.4)	.029
Competition level						
None	—	—	—	—	—	—
Recreational	0.26 (–3.92 to 4.43)	.904	–5.61 (–15.07 to 3.85)	.244	–0.44 (–5.89 to 5)	.873
Competitive	0.78 (–3.93 to 5.49)	.745	–2.85 (–13.53 to 7.84)	.601	0.34 (–5.81 to 6.48)	.914
Graft						
BTB autograft	—	—	—	—	—	—
Hamstring autograft	0.49 (–1.37 to 2.36)	.603	1.34 (–2.95 to 5.63)	.54	0.72 (–1.72 to 3.16)	.561
Allograft	1.59 (–1.09 to 4.26)	.244	–3.62 (–9.74 to 2.49)	.245	–0.38 (–3.88 to 3.13)	.833
Medial meniscal treatment						
None	—	—	—	—	—	—
Excision	1.11 (–1.02 to 3.25)	.306	2.8 (–2.06 to 7.66)	.259	2.61 (–0.18 to 5.39)	.067
Repair	0.72 (–1.32 to 2.75)	.489	–1.23 (–5.87 to 3.41)	.603	0.05 (–2.6 to 2.7)	.97
Lateral meniscal treatment						
None	—	—	—	—	—	—
Excision	0.85 (–0.83 to 2.52)	.32	4.25 (0.42 to 8.09)	.03	0.51 (–1.68 to 2.71)	.646
Repair	0.08 (–3.21 to 3.38)	.96	–2.74 (–10.26 to 4.78)	.474	–0.64 (–4.95 to 3.67)	.771
Surgery type						
Primary	—	—	—	—	—	—
Revision	–4.65 (–7.94 to –1.35)	.006	–8.83 (–16.36 to –1.31)	.022	–6.05 (–10.36 to –1.74)	.006
No. of people in household	0.08 (–0.41 to 0.57)	.753	–0.1 (–1.23 to 1.02)	.859	0.03 (–0.61 to 0.67)	.925
Baseline score	0.22 (0.17 to 0.27)	<.001	0.25 (0.17 to 0.34)	<.001	0.28 (0.22 to 0.34)	<.001
Baseline Marx score	0.03 (–0.15 to 0.21)	.742	0.19 (–0.23 to 0.6)	.383	0.15 (–0.08 to 0.39)	.206
Education	–0.07 (–0.73 to 0.59)	.826	–2.3 (–3.8 to –0.79)	.003	–0.61 (–1.48 to 0.25)	.166
Employment status						
Unemployed	—	—	—	—	—	—
Part-time	2.24 (–0.4 to 4.88)	.096	1.3 (–4.75 to 7.34)	.674	2 (–1.46 to 5.45)	.256
Full-time	1.06 (–1.76 to 3.88)	.461	1.73 (–4.73 to 8.19)	.6	2.18 (–1.51 to 5.87)	.247
Student						
No	—	—	—	—	—	—
Yes	1.31 (–1.62 to 4.25)	.381	3.94 (–2.77 to 10.66)	.249	1.54 (–2.3 to 5.39)	.43
Disabled						
No	—	—	—	—	—	—
Yes	–1.56 (–6.43 to 3.32)	.531	–9.14 (–20.2 to 1.93)	.106	–0.49 (–6.83 to 5.85)	.879
Interaction (age, education)	0.02 (0 to 0.05)	.066	0.09 (0.04 to 0.14)	.001	0.04 (0.01 to 0.07)	.014

[a]Dashes indicate reference variable. ADL, Activities of Daily Living; BMI, body mass index; BTB, bone–patellar tendon–bone; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; QoL, Quality of Life.

TABLE A4
Coefficients and *P* Values for the Clinical + A Model for KOOS Sports&Rec, Symptoms, Marx, and IKDC Outcomes[a]

	Sports&Rec		Symptom		Marx Activity		IKDC	
Variable	Effect (95% CI)	*P*	Effect (95% CI)	*P*	Effect (95% CI)	*P*	Effect (95% CI)	*P*
Age	–1.04 (–1.87 to –0.21)	.014	–0.57 (–1.16 to 0.03)	.061	–0.18 (–0.36 to 0)	.049	–0.59 (–1.19 to 0.01)	.055
Sex								
Female	—	—	—	—	—	—	—	—
Male	–0.94 (–4.44 to 2.55)	.596	–0.11 (–2.58 to 2.36)	.93	1.11 (0.37 to 1.84)	.003	1.28 (–1.2 to 3.76)	.311
Race								
White	—	—	—	—	—	—	—	—
Black	–1.11 (–7.07 to 4.85)	.715	1.1 (–3.18 to 5.38)	.614	–1.09 (–2.37 to 0.18)	.093	1.62 (–2.65 to 5.88)	.457
Other	–2.5 (–10.62 to 5.62)	.546	–3.6 (–9.43 to 2.22)	.225	0.15 (–1.59 to 1.89)	.864	–1.54 (–7.36 to 4.27)	.602
BMI	–0.38 (–0.78 to 0.01)	.059	–0.33 (–0.62 to –0.05)	.02	–0.09 (–0.17 to 0)	.046	–0.37 (–0.66 to –0.09)	.011
Smoking status								
Never	—	—	—	—	—	—	—	—
Quit	–1.65 (–7.52 to 4.22)	.581	–3.69 (–7.81 to 0.43)	.079	–1.58 (–2.82 to –0.34)	.012	–2.18 (–6.44 to 2.09)	.317
Current	–10.71 (–16.68 to –4.73)	<.001	–6.15 (–10.46 to –1.85)	.005	–1.45 (–2.72 to –0.18)	.026	–5.93 (–10.2 to –1.66)	.007
Competition level								
None	—	—	—	—	—	—	—	—
Recreational	–2.87 (–11.99 to 6.25)	.537	–2.11 (–8.61 to 4.38)	.523	–0.32 (–2.32 to 1.68)	.756	–0.15 (–6.79 to 6.5)	.966
Competitive	–2.86 (–13.17 to 7.45)	.586	–3.67 (–11.01 to 3.67)	.326	0.84 (–1.41 to 3.09)	.462	0.46 (–7 to 7.92)	.904
Graft								
BTB autograft	—	—	—	—	—	—	—	—
Hamstring autograft	2.01 (–2.14 to 6.17)	.342	0.44 (–2.48 to 3.37)	.767	–0.39 (–1.26 to 0.49)	.385	2.44 (–0.49 to 5.37)	.102
Allograft	1.07 (–4.74 to 6.88)	.718	–1.28 (–5.47 to 2.92)	.55	–2.05 (–3.3 to –0.79)	.001	0.42 (–3.79 to 4.62)	.846
Medial meniscal treatment								
None	—	—	—	—	—	—	—	—
Excision	1.06 (–3.64 to 5.76)	.658	0.75 (–2.59 to 4.08)	.661	0.13 (–0.87 to 1.12)	.805	1.54 (–1.82 to 4.89)	.368
Repair	0.02 (–4.51 to 4.55)	.993	–1.13 (–4.3 to 2.05)	.486	–0.65 (–1.6 to 0.3)	.183	0.88 (–2.31 to 4.08)	.587
Lateral meniscal treatment								
None	—	—	—	—	—	—	—	—
Excision	2.42 (–1.29 to 6.13)	.2	0.98 (–1.64 to 3.61)	.462	0.77 (–0.02 to 1.56)	.055	1.89 (–0.76 to 4.53)	.162
Repair	–1.44 (–8.6 to 5.72)	.693	0.94 (–4.22 to 6.09)	.721	0.44 (–1.12 to 2)	.578	–0.17 (–5.31 to 4.97)	.949
Surgery type								
Primary	—	—	—	—	—	—	—	—
Revision	–4.69 (–11.85 to 2.47)	.199	–1.69 (–6.86 to 3.49)	.522	–0.99 (–2.53 to 0.55)	.207	–7.6 (–12.76 to –2.45)	.004
No. of people in household	0.05 (–1.04 to 1.13)	.93	0 (–0.78 to 0.77)	.99	0.05 (–0.18 to 0.28)	.678	0.13 (–0.65 to 0.91)	.744
Baseline score	0.15 (0.09 to 0.21)	<.001	0.26 (0.19 to 0.33)	<.001			0.32 (0.24 to 0.39)	<.001
Baseline Marx score	0.1 (–0.31 to 0.5)	.639	0.05 (–0.23 to 0.34)	.707	0.35 (0.26 to 0.44)	<.001	0.24 (–0.05 to 0.53)	.1
Education	–1.29 (–2.74 to 0.16)	.08	–1 (–2.04 to 0.03)	.058	–0.37 (–0.68 to –0.06)	.019	–0.71 (–1.76 to 0.33)	.181
Employment status								
Unemployed	—	—	—	—	—	—	—	—
Part-time	–3.5 (–9.32 to 2.33)	.239	1.49 (–2.64 to 5.63)	.479	0.69 (–0.55 to 1.93)	.277	1.58 (–2.57 to 5.74)	.455
Full-time	–0.5 (–6.86 to 5.86)	.877	0.93 (–3.49 to 5.36)	.679	0.28 (–1.05 to 1.62)	.675	2.05 (–2.4 to 6.51)	.366
Student								
No	—	—	—	—	—	—	—	—
Yes	–0.93 (–7.49 to 5.63)	.782	–0.25 (–4.87 to 4.36)	.914	1.12 (–0.26 to 2.5)	.112	4.43 (–0.24 to 9.1)	.063
Disabled								
No	—	—	—	—	—	—	—	—
Yes	–6.05 (–17.54 to 5.44)	.302	0.88 (–6.76 to 8.51)	.822	–3.58 (–5.89 to –1.27)	.002	–0.45 (–8.2 to 7.31)	.91
Interaction (age, education)	0.06 (0.01 to 0.12)	.02	0.04 (0 to 0.08)	.031	0.01 (0 to 0.02)	.03	0.04 (0 to 0.08)	.032

[a]Dashes indicate reference variable. Gray shading indicates parameters that were not included in the model for that column. BMI, body mass index; BTB, bone–patellar tendon–bone; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx activity rating scale; Sports&Rec, Sports and Recreation.