Original Article

Body Mass Index Between 15 and 30 Does Not Influence Patient-Reported Outcomes After Anterior Cruciate Ligament Surgery Using a 10-mm-Diameter Bone-Tendon-Bone Graft

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Purpose: To investigate the relation between body mass index (BMI) and outcomes after anterior cruciate ligament reconstruction (ACLR) using 10-mm-diameter bone—patellar tendon—bone grafts. **Methods:** In this retrospective study, the Surgical Outcome System was used to measure patient-reported outcomes before and after ACLR between 2015 and 2019. The inclusion criteria consisted on patients undergoing primary ACLR performed by the senior surgeon, with recorded age of 15 years or older and BMI of 15.0 to 30. The exclusion criteria included revisions, concomitant procedures, age younger than 15 years, and unknown BMI. Patients were divided into cohorts to evaluate the Marx Activity Rating Scale (MARS), Tegner, International Knee Documentation Committee (IKDC), and Lysholm scores at various time points from injury to 2 years postoperatively. **Results:** A total of 137 patients (100 male and 37 female patients) with an average age of 33 years (95% confidence interval, 30.6-35.4 years) and average BMI of 23.58 (95% confidence interval, 23.1-24.0) were divided into those with a BMI of 15 to 23.4 (group A, n = 69) and those with a BMI of 23.5 to 30 (group B, n = 68). A significant difference in MARS scores was found between the BMI groups before treatment, with mean scores of 11.55 (group A) and 9.41 (group B) ($P = .011$), and Tegner scores showed significance at 2 years, with scores of 6.45 and 5.41 for groups A and B, respectively ($P = .009$). Daily function scores were all insignificant. Female patients exhibited no significant differences across any patient-reported outcome measures or time points. Contrarily, male patients showed a significant difference in pretreatment MARS scores (14.30 in group A vs 9.96 in group B, $P = .011$). Additionally, scores at 2 years depicted Tegner values of 7.40 in group A versus 5.30 in group B ($P = .012$) and IKDC values of 96.92 in group A versus 90.47 in group B ($P = .048$). All results for female and male patients aged 30 years or younger indicated no significance. **Conclusions:** Regardless of patient age or sex, BMI is not significantly associated with patient-reported outcomes after ACLR using 10-mm-diameter bone—patellar tendon—bone grafts. **Level of Evidence:** Level III, retrospective cohort study.

Anterior cruciate ligament reconstruction (ACLR) procedures are exceedingly prevalent treatments for anterior cruciate ligament (ACL) tears in athletes.[1,2] In the United States, 120,000 to 200,000 ACLR procedures are performed annually, with ACL injuries comprising 64% of sports-related knee injuries.[1,2] Although substantial medical developments have improved intervention techniques and outcomes, the extent to which body mass index (BMI) affects recovery, function, and return to sport (RTS) after ACLR remains unclear. Typically, athletes experience an increased risk of primary ACL rupture and, consequently, endure the bulk of ACL injuries owing to frequent cutting, jumping, decelerating, and direct colliding.[2] Recently, sport-related ACL injuries have been rising in younger populations, and the risk of damage is 3 to 8 times greater in women compared with men.[3]

Although conservative management is feasible, ACLR is encouraged for active individuals who anticipate returning to preinjury functional levels.[2,4] To achieve

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desired outcomes, appropriate graft type and size determination possesses prime significance.[5] Various graft types including bone−patellar tendon−bone (BPTB), hamstring tendon, and quadriceps tendon are widely known for yielding surgical success.[6,7] As opposed to hamstring tendon and quadriceps tendon grafts, the literature has proposed that BPTB implementation decreases retear rates while yielding higher RTS scores closest to preinjury levels.[4,7]

BMI assesses body composition and health status according to height and weight. Although there are acknowledgeable drawbacks, BMI remains a strong tool and is correlated with various health and musculoskeletal outcomes.[8,9] Consequently, differing BMI ranges may lead to various ACLR results, such as functional outcomes, graft healing, and RTS progression. Furthermore, preferred graft size is currently debatable. Larger grafts show an advantage after ACLR regarding ligament strength and force, but some surgeons believe that smaller patients may face increased chances of secondary graft issues such as impingement or stiffness.[10,11] Therefore, investigating the relevance of BMI as a predictive variable during graft determination enables patient-specific treatment strategies and enhanced long-term results.

Prior literature has also addressed the relation between BMI and total knee arthroplasty outcomes, indicating a negative correlation.[12,13] Higher BMIs are associated with suboptimal patient-reported outcome scores in related orthopaedic procedures,[12,13] which provides a foundation to expand the research and target ACLR outcomes exclusively.

The purpose of this study was to investigate the relation between BMI and outcomes after anterior cruciate ligament reconstruction (ACLR) using 10-mm-diameter BPTB grafts. We hypothesized that BMI would produce negligible effects on ACLR outcome scores for any population.

Methods

After obtaining institutional review board approval, we performed this retrospective database analysis using the Surgical Outcome System (SOS) (Arthrex, Naples, FL) to evaluate patient-reported outcome measures (PROMs) before and after ACLR using 10-mm-wide BPTB autograft and BPTB allograft performed by a single surgeon (P.A.) between 2015 and 2019. The inclusion criteria consisted of patients undergoing ACLR who fell within a BMI range of 15 to 30 and were aged 15 years or older. The exclusion criteria included any revision ACL surgery, meniscal surgery (resection or repair), intraoperative chondral damage grade 2 or greater per the Outerbridge classification, concomitant ligament surgery, and BMI <15 or BMI >30. The BMI cutoff > 30 was selected to reflect Centers for Disease Control and Prevention guidelines, which recognize BMI >30 as the official cutoff for "obese."[14,15]

Indications for surgery involved radiographic evidence of ACL insufficiency or tearing with clinical evidence of ACL laxity and complaints of instability. All surgical procedures were performed via an anteromedial-portal flexible-reamer femoral technique with absorbable interference screw fixation (Milagro interference screw; DePuy Synthes, Raynham, MA) on the femoral and tibial sides.

The Tegner, Marx Activity Rating Scale (MARS), International Knee Documentation Committee (IKDC), and Lysholm scores were selected for assessment preoperatively and postoperatively owing to their validity and established clinical application.[16,17] Preoperatively, standard scoring questionnaires were distributed, with the MARS score evaluating the highest level of activity in the past year with the knee in a healthy state (with higher scores signifying greater activity levels), the Tegner score evaluating the highest level of activity with the currently injured knee (with higher scores indicating higher sport levels), and the IKDC and Lysholm scores evaluating the overall function of the currently injured knee (with higher scores denoting greater knee function and less pathology).[16] Tegner, IKDC, and Lysholm scores were recorded postoperatively at 6, 12, and 24 months. MARS scores were recorded at 12 and 24 months. Tegner and MARS scores were primary measures; IKDC and Lysholm scores were secondary measures. Patients were separated into 2 groups: those undergoing ACLR using 10-mm BPTB autograft (or allograft) whose BMI was between 15 and 23.4 (group A) and those undergoing ACLR using 10-mm BPTB autograft (or allograft) whose BMI was between 23.5 and 30 (group B).

Statistical Analysis

Statistical analysis was performed using RStudio (version 2023.06.0+421). Continuous variables were reported as means, and categorical variables were reported as percentages. The significance level (α) was set at $P < .05$. Homogeneity of variance was assessed using the Levene test, and normality of PROMs was assessed at each time point using the Shapiro-Wilk test. Univariate analysis for the 4 PROMs for both male and female patients was performed at each time point using the nonparametric Mann-Whitney *U*/Wilcoxon rank sum test with continuity correction.

Results

Demographic Characteristics

The overall cohort consisted of 137 patients (37 male and 98 female patients) who underwent ACLR. Patients were categorized by age, sex (72% female and 27% male), and BMI subgroup (Table 1). BMI was classified as lower BMI (group A), with a mean value of 21.42 (95% confidence interval [CI], 21.1-21.8), or higher BMI (group B), with a mean value of 25.78 (95% CI,

25.4-26.2) (Table 1). Patient demographic data for the sample aged 30 years or younger (n = 65) exhibited BMI averages of 21.6 (95% CI, 21.1-22.0) for the lower BMI group and 25.3 (95% CI, 24.7-26.0) for the higher BMI group (Table 2).

Outcome Measures for Collective Sample

Prior to analyzing the PROM scores by sex, we analyzed the collective outcomes. Because the MARS pretreatment scores between the higher and lower BMI groups showed a significant difference, our study compared the differences in score values between groups from before treatment to after treatment rather than comparing the numerical score values at the post-treatment follow-up assessments. The MARS results indicated a significant difference in scores before treatment (11.55 in group A vs 9.41 in group B, $P = .011$), showing a 2.14 score drop, but no significant differences between score changes at 1 or 2 years postoperatively (Table 3). Dissimilar to the MARS analysis, the Tegner, IKDC, and Lysholm PROMs presented comparable pretreatment baseline scores and enabled numerical score comparison between groups at each time point. No distinctive differences were observed for the IKDC or Lysholm outcomes at any time point (Table 3). The Tegner data identified a significant variation at the 2-year follow-up (6.45 in group A vs 5.41 in group B, $P = .009$) compared with any other time point measured (Table 3).

Outcome Measures by Sex

PROM scores based on sex were supplementarily extracted and investigated. The predominant data among female patients showed no differences in average Tegner, IKDC, or Lysholm scores at any time point (Table 4). The MARS data additionally presented no significant differences in score changes between groups A and B at 1 or 2 years (Table 4).

As shown in Table 5, the data pertaining to male patients showed multiple statistically significant results for the MARS, Tegner, and IKDC outcomes. In contrast to the female sample, the male sample showed a 4.34 score difference between groups A and B on the MARS pretreatment evaluation, with average values of 14.30 and 9.96, respectively ($P = .011$) (Table 5). Additionally, 2-year Tegner values displayed a 2.1 score difference between groups ($P = .012$) (Table 5). Finally, the IKDC scores at the 2-year mark showed a 6.45 difference between groups (96.92 in group A vs 90.47 in group B, $P = .048$) (Table 5). The Lysholm outcomes and all other results presented in Table 5 that are not mentioned in this section introduced no statistical significance.

Outcome Measures by Age

Outcome measures from the cohorts categorized by sex were further stratified to gather in-depth data regarding patients aged 30 years or younger. The PROM scores for both the female and male patients lacked statistical significance, and mean values were comparable between the 2 groups for the Tegner, IKDC, and Lysholm scores at all time points (Table 6). Furthermore, MARS score differences from before treatment to 1 and 2 years postoperatively showed no statistical significance for either sex (Table 6).

Discussion

Our data suggest no outcome differences in PROMs between the 2 BMI groups while strictly using 10-mm BPTB grafts for ACLR. Despite limited significant findings in the comprehensive sample, the results largely remained insignificant. Considerable research has supported the notion that increased BMI and obesity have implications on total joint arthroplasty outcomes,[12,13,18] but our study targets ACLR results directly—and further emphasizes specific demographic populations. Several variables may influence the negative results observed in higher BMI groups after arthroplasty, such as weight-bearing implants enduring increased loads or rising infection rates corresponding to elevated BMI,[12,18] but these results do not definitively translate to other knee procedures. Accordingly, ACLR procedures have been associated with an elevated risk of postoperative osteoarthritis in patients with BMI > 25,[19-22] increasing the likelihood of negative long-term outcomes. Higher BMIs are also associated with an increased risk of revision surgery,[23] suggesting a prolonged recovery after ACLR. Despite the abundance of information surrounding BMI and arthroplasty outcomes, there is limited knowledge on the exclusive relation between BMI and ACLR.

Previous studies have consistently deemed the impact of BMI on arthroscopic knee procedure outcomes inconclusive. Kluczynski et al.[12] aimed to culminate a supported conclusion on the impact of BMI on knee and shoulder operations but produced incongruous results, despite alternative literature associating higher BMIs (>25) with worse clinical scores, lower activity levels, and reduced patient satisfaction after various arthroscopic knee operations.[18] Although lower IKDC scores consistently coincide with higher BMI ranges after ACLR, the variable alone is not a valuable outcome predictor.[19,24] Given the multitude of covariables, it is challenging to pinpoint BMI as having a strong influence on the observed outcomes.

Concurrently, graft dimensions play a key role in patient-reported outcomes in ACLR patients. Knee function outcomes exhibit a relation with the native ACL diameter, and moreover, a 10% increase in the new graft diameter maximizes knee force and stability.[10] Duerr et al.[25] similarly found that diameter increases even as minimal as 1 mm improved PROMs as

Table 1. Demographic Characteristics of Entire Patient Cohort

	Group A (BMI of 15-23.4), n = 69	Group B (BMI of 23.5-30), n = 68	*P* Value	All Patients, N = 137
Age, yr	31.3 (27.8-34.8)	34.7 (31.4-38.0)	.12	33.0 (30.6-35.4)
BMI	21.4 (21.1-21.8)	25.8 (25.4-26.2)	<.001**	23.6 (23.1-24.0)
Sex				
Female	57 (83)	41 (60)	.13	98 (72)
Male	10 (14)	27 (40)		37 (27)
Graft type				
Autograft	44 (64)	40 (59)	.675	84 (61)
Allograft	25 (36)	28 (41)		53 (39)
Pretreatment PROMs				
MARS score	11.55 ± 5.3	9.41 ± 5.26	.011*	
Tegner score	4.32 ± 2.63	3.75 ± 2.43	.223	
IKDC score	52.04 ± 13.43	52.09 ± 13.37	>.999	
Lysholm score	66.49 ± 16.69	64.63 ± 16.76	.498	

NOTE. *P* values show comparisons between groups A and B. *P* values for age, BMI, and preoperative PROM scores were calculated using the Kruskal-Wallis rank sum test, whereas *P* values for sex were calculated using the χ^2 test. Age and BMI are reported as mean (95% confidence interval), pretreatment PROM scores are reported as mean ± standard deviation, and sex and graft type are reported as frequency (percentage of total group). The sex of 2 group A patients was unknown.

BMI, body mass index; IKDC, International Knee Documentation Committee; MARS, Marx Activity Rating Scale; PROM, patient-reported outcome measure.

*$P < .05$.

**$P < .001$.

assessed using the Knee Injury and Osteoarthritis Outcome Score (KOOS) pain, symptom, and sport subscales. Larger grafts additionally reduce the probability of revision ACLR, with a minimum of 7 mm.[26] Although an abundance of knowledge sheds light on ACLR outcomes regarding graft size, BMI and hamstring grafts are largely controlled to evaluate age differences and limit confounding variables.[27-29] Because BMI generally remains consistent, prior research has neglected the effect of BMI or significance of BMI in terms of graft size determination.

The configuration and measurements of the joint's structures provide essential data regarding the native ACL dimensions.[30] Notably, the width of the femoral condyle is associated with the native ACL width, rendering numerical guidance for graft determination.[30] Combined with femoral measurements, the intercondylar notch space implements complementary parameters because grafts proportionally large to the available space provoke impingement.[11] Hence, repetitive impingement yields ligament damage and delayed healing.[11,31,32] These implications aid graft evaluation

Table 2. Demographic Characteristics of Patients Aged 30 Years or Younger

	Group A (BMI of 15-23.4), n = 37	Group B (BMI of 23.5-30), n = 28	*P* Value
Age, yr	19.1 (17.9-20.3)	21.6 (19.6-23.6)	.035*
BMI	21.6 (21.1-22.0)	25.3 (24.7-26.0)	<.001**
Sex			
Female	29 (78)	16 (57)	.118
Male	7 (19)	12 (43)	
Pretreatment PROMs			
MARS score	13.27 ± 4.69	11.54 ± 5.43	.118
Tegner score	4.68 ± 2.97	4.29 ± 2.83	.633
IKDC score	55.71 ± 12.80	54.31 ± 12.18	.786
Lysholm score	69.12 ± 15.41	66.07 ± 16.03	.337
Graft type			
Autograft	37 (100)	28 (100)	
Allograft	0 (0)	0 (0)	

NOTE. *P* values for age, BMI, and preoperative PROM scores were calculated using the Kruskal-Wallis rank sum test, whereas *P* values for sex were calculated using the χ^2 test. Age and BMI are reported as mean (95% confidence interval), pretreatment PROM scores are reported as mean ± standard deviation, and sex and graft type are reported as frequency (percentage of total group). The sex of 1 group A patient was unknown.

BMI, body mass index; IKDC, International Knee Documentation Committee; MARS, Marx Activity Rating Scale; PROM, patient-reported outcome measure.

*$P < .05$.

**$P < .001$.

Table 3. Mean PROM Scores of Patients Who Underwent ACLR With 10-mm BPTB Grafts

Time	Mean		*P* Value
	Group A (BMI of 15-23.49), n = 69	Group B (BMI of 23.5-30), n = 68	
MARS score			
Before treatment	11.55	9.41	.011*
Before treatment to 1 yr postoperatively	−3.20	−2.49	.293
Before treatment to 2 yr postoperatively	−2.25	−2.13	.928
Tegner score			
Before treatment	4.32	3.75	.223
6 mo postoperatively	3.93	3.93	.807
1 yr postoperatively	5.83	5.41	.470
2 yr postoperatively	6.45	5.41	.009**
IKDC score			
Before treatment	52.04	52.09	>.999
6 mo postoperatively	67.46	66.98	.778
1 yr postoperatively	82.00	80.51	.436
2 yr postoperatively	88.26	88.21	.471
Lysholm score			
Before treatment	66.49	64.63	.498
6 mo postoperatively	82.72	83.93	.374
1 yr postoperatively	90.88	89.37	.469
2 yr postoperatively	91.61	92.93	.814

NOTE. *P* values were calculated using the Mann-Whitney *U*/Wilcoxon rank sum test.

ACLR, anterior cruciate ligament reconstruction; BMI, body mass index; BPTB, bone−patellar tendon−bone; IKDC, International Knee Documentation Committee; MARS, Marx Activity Rating Scale; PROM, patient-reported outcome measure.

*$P < .05$.

**$P < .01$.

and selection. The decision remains complex because a larger graft benefits function, stability, and retear risk,[10,25,26] but the risk of impingement in a patient with smaller features can elicit disadvantages for healing and future injury.[11,31,32] A notchplasty eliminates a negligible amount of bone to expand the intercondylar notch space, therefore minimizing the frequency and consequences of impingement.[33] Although it can be argued that joint structures correspond to BMI, Oshima et al.[11] concluded that the intercondylar notch space

Table 4. Mean PROM Scores of Female Patients Who Underwent ACLR With 10-mm BPTB Grafts

Time	Mean		*P* Value
	Group A (BMI of 15-23.49), n = 57	Group B (BMI of 23.5-30), n = 41	
MARS score			
Before treatment	10.96	9.05	.097
Before treatment to 1 yr postoperatively	−3.04	−3.20	.986
Before treatment to 2 yr postoperatively	−2.00	−2.54	.655
Tegner score			
Before treatment	4.35	3.98	.476
6 mo postoperatively	3.86	4.05	.544
1 yr postoperatively	5.70	5.34	.609
2 yr postoperatively	6.3	5.59	.089
IKDC score			
Before treatment	52.13	51.05	.604
6 mo postoperatively	66.29	67.83	.746
1 yr postoperatively	80.38	77.98	.316
2 yr postoperatively	86.83	86.72	.417
Lysholm score			
Before treatment	66.39	62.61	.237
6 mo postoperatively	81.44	83.05	.403
1 yr postoperatively	90.23	87.05	.179
2 yr postoperatively	90.70	91.34	.962

NOTE. *P* values were calculated using the Mann-Whitney *U*/Wilcoxon rank sum test.

ACLR, anterior cruciate ligament reconstruction; BMI, body mass index; BPTB, bone−patellar tendon−bone; IKDC, International Knee Documentation Committee; MARS, Marx Activity Rating Scale; PROM, patient-reported outcome measure.

Table 5. Mean PROM Scores of Male Patients Who Underwent ACLR With 10-mm BPTB Grafts

Time	Mean		*P* Value
	Group A (BMI of 15-23.49), n = 10	Group B (BMI of 23.5-30), n = 27	
MARS score			
Before treatment	14.30	9.96	.011*
Before treatment to 1 yr postoperatively	−3.40	−1.41	.145
Before treatment to 2 yr postoperatively	−3.20	−1.52	.439
Tegner score			
Before treatment	4.60	3.41	.267
6 mo postoperatively	4.50	3.74	.233
1 yr postoperatively	6.40	5.52	.313
2 yr postoperatively	7.40	5.30	.012*
IKDC score			
Before treatment	51.04	53.68	.644
6 mo postoperatively	75.88	65.70	.060
1 yr postoperatively	90.02	84.35	.193
2 yr postoperatively	96.92	90.47	.048*
Lysholm score			
Before treatment	67.30	67.70	.959
6 mo postoperatively	90.10	85.26	.272
1 yr postoperatively	95.60	92.89	.264
2 yr postoperatively	98.40	95.33	.089

NOTE. *P* values were calculated using the Mann-Whitney *U*/Wilcoxon rank sum test.

ACLR, anterior cruciate ligament reconstruction; BMI, body mass index; BPTB, bone−patellar tendon−bone; IKDC, International Knee Documentation Committee; MARS, Marx Activity Rating Scale; PROM, patient-reported outcome measure.

*$P < .05$.

constitutes a stronger association with native ACL size as opposed to height or weight. The accumulated literature has exposed a gap distinguishing the relation between ACLR outcomes with controlled 10-mm grafts and various BMI ranges.

The overall sample data suggest that BMI has no effect on ACLR patient-reported outcomes, in which the grafts were standardized to 10 mm and BPTB. Although there may be some hesitation for incorporating larger grafts in lower BMI patients, no observed disadvantages arose in our study, and larger grafts historically have produced preferable outcomes. Because the results pertain to specific graft requirements, it is relevant to acknowledge that our results are not generalizable to all grafts. This analysis aligns with preceding literature suggesting no correlation between various BMI ranges and patient-reported knee outcomes in the comprehensive sample. Although the whole sample cannot signify a well-supported association, the subsequent demographic cohorts reinforce the verdict by attaining analogous results.

Female Patients

Traditionally, female patients are more prone to experience ACL tears and undergo ACLR.[3,34] Evaluating female outcome scores independently furthers knee function perspective and RTS after surgery. The scores reported from preoperatively to the final evaluation at 2 years postoperatively in the BMI groups exhibited a drastic improvement for the IKDC and Lysholm PROMs, suggesting that knee function and activity and/or RTS improve significantly during this interval. Since BMI groups A and B increase in parallel, BMI does not impact female outcomes.

In contrast to the IKDC and Lysholm outcomes, the MARS scores decreased from before treatment to 2 years postoperatively in both groups. Although several integrated factors contribute to decreased sports participation, an abundance of research reinforces mental inhibition factors stemming from the relation between the initial ACL injury and associated skills.[34-38] The ACL Return to Sport After Injury (ACL-RSI) evaluation is a reliable psychological screening questionnaire to assess mental readiness for RTS.[36] Recently, more focus has been targeting the psychological component of RTS because fear of reinjury and knee confidence variables are gaining direct attention.[38] Despite the paucity of statistically significant results among female patients, both BMI groups showed decreased knee function and activity levels, rendering fear of reinjury and self-efficacy likely factors in RTS.[35,38] Although group B reported substantially lower MARS scores than group A at both 1 and 2 years, the changes in scores are not significant because they rely on differing pretreatment values.

Further division of the female sample allows for comparison between the entire female cohort and female patients aged 30 years or younger. All of the results are strikingly similar, showing comparable increases in both groups' Tegner, IKDC, and Lysholm

Table 6. Mean PROM Scores of Female and Male Patients Aged 30 Years or Younger Who Underwent ACLR With 10-mm BPTB Grafts

	Mean		
Time	Group A (BMI of 15-23.49)	Group B (BMI of 23.5-30)	*P* Value
Female patients	n = 29	n = 16	
MARS score			
Before treatment	12.97	12.13	.528
Before treatment to 1 yr postoperatively	−2.28	−3.00	.829
Before treatment to 2 yr postoperatively	−0.48	−2.38	.091
Tegner score			
Before treatment	4.79	4.38	.597
6 mo postoperatively	4.59	5.00	.652
1 yr postoperatively	6.72	6.94	.819
2 yr postoperatively	7.31	7.19	.672
IKDC score			
Before treatment	56.13	50.29	.196
6 mo postoperatively	70.37	69.84	.822
1 yr postoperatively	85.4	81.33	.308
2 yr postoperatively	90.51	87.96	.432
Lysholm score			
Before treatment	68.48	63.06	.196
6 mo postoperatively	83.07	83.5	.652
1 yr postoperatively	90.76	86.75	.165
2 yr postoperatively	90.48	90.94	.727
Male patients	n = 7	n = 12	
MARS score			
Before treatment	14.14	10.75	.227
Before treatment to 1 yr postoperatively	−3.57	−0.83	.329
Before treatment to 2 yr postoperatively	−3.14	−1.17	.580
Tegner score			
Before treatment	4.43	4.17	>.999
6 mo postoperatively	4.43	4.17	.966
1 yr postoperatively	6.43	6.08	.862
2 yr postoperatively	7.29	5.42	.102
IKDC score			
Before treatment	53.54	59.68	.499
6 mo postoperatively	72.59	72.33	>.999
1 yr postoperatively	89.84	86.22	.832
2 yr postoperatively	95.91	91.1	.523
Lysholm score			
Before treatment	72.00	70.08	.767
6 mo postoperatively	89.57	84.83	.581
1 yr postoperatively	95.71	94.33	.965
2 yr postoperatively	97.71	97.08	.845

NOTE. *P* values were calculated using the Mann-Whitney *U*/Wilcoxon rank sum test.

ACLR, anterior cruciate ligament reconstruction; BMI, body mass index; BPTB, bone—patellar tendon—bone; IKDC, International Knee Documentation Committee; MARS, Marx Activity Rating Scale; PROM, patient-reported outcome measure.

scores and similar decreases in MARS scores. The outcomes provide additional support suggesting that BMI has no influence on ACL PROM scores even when targeting a younger female population.

Male Patients

In contrast to the female cohort, the isolated male sample revealed different trends. Notably, male patients showed a significant difference in MARS scores between BMI groups before treatment, contradicting the female pretreatment significance. Conversely, the male MARS results elicited no significant differences between the score changes at 1 and 2 years, corresponding favorably with the female results. The considerably higher baseline MARS scores in group A suggest engagement in running, cutting, and pivoting more frequently prior to injury than in group B. Yet, regardless of pretreatment disparity, the MARS postoperative evaluations yield the conclusion that BMI does not affect activity levels after ACLR.

The Tegner and IKDC outcomes also established valuable differences between BMI groups. In both instances, at the 2-year follow-up assessment, group B displayed lower scores than group A, denoting lower

knee function, higher symptoms, and decreased perceived sport performance. Although acknowledging these disparities is important, the male patients in each BMI group were distributed unevenly, implicating the mean PROM values and statistical analysis. The number of male patients in the small group accounted for only one-third of the cohort and, therefore, makes the results challenging to accredit. The Lysholm results and other nonsignificant results may be attributable to a type II error due to low power and should be further investigated in future research to narrow the focus with comparable but larger samples.

Outcome scores for male patients aged 30 years or younger were analyzed to identify generalizability and trends between age populations. Much like the BMI groups for all male patients, the male cohort aged 30 years or younger does not segregate equally between the 2 BMI ranges, causing potential inaccuracies in the results. No significant differences were exemplified, thus promoting a consensus stating that BMI does not have an appreciable impact on perceived outcomes after ACLR.

This study enhances the growing medical field by shedding light on the clinical application of successful ACLR and clarifying how BMI correlates with subjective outcomes. The interpretations suggest that there are no valuable discrepancies between BMI groups in clinical practice for men or women undergoing ACLR surgery with 10-mm BPTB grafts. Because most ACLR patients are aged younger than 30 years and plausibly athletes eager to RTS, a focus on the latter findings supports that ACLR outcomes will not waiver regarding BMI ranges.

Limitations

This study possesses limitations that warrant attention. First, the BMI ranges selected for the distinct groups were determined to increase the validity of comparisons across groups. The selected cutoffs were determined by the patient population BMI range at the time of surgery, in collaboration with the Centers for Disease Control and Prevention's established obese cutoff accounting for BMI > 30. Allowing for an accurate correspondence involved dividing the participants equally to increase the power of hypothesis tests. Although the mean BMI values were significantly different ($P < .001$), we recognize that the distributions among the groups were inherently skewed toward the cutoff. Second, BMI may not be the most appropriate variable to determine significant distinctions in ACLR outcomes. BMI does not account for muscle mass or body fat percentage, which can be further explored in the future to focus the outcomes with respect to health, fitness, and strength. Our study does not account for bony structures and measurements. It is encouraged that upcoming research examine the relation between the intercondylar notch space and BMI to attribute potential underlying factors that correspond to individual knee anatomy. The collective sample size provides respectable BMI cohorts, but on continuous stratification, the sample sizes are limited, and we did not perform an a priori sample size calculation. In turn, this analysis may possess low power, which can cause false-negative findings (type II error) and ultimately inhibits a comprehensive understanding with generalizable conclusions. The final limitation originates from the inclusion of patients treated by a single surgeon. The absence of combined surgeon results might inhibit wide generalizability.

Conclusions

Regardless of patient age or sex, BMI is not significantly associated with patient-reported outcomes after ACLR using 10-mm-diameter BPTB grafts.

Disclosures

All authors (M.A.L., S.H., B.F., N.S., P.A.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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