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Predictors of Patient Reported Outcomes of Total Joint Arthroplasty in a Developing Country

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Abstract

Background: In response to the growing burden of joint disease, developing countries are starting to create their own total joint arthroplasty (TJA) programs. To date, there has been limited research on predictors of TJA outcomes in a developing country. This investigation uses patient-reported outcome measures (PROMs) collected by a medical mission to assess predictors of TJA outcomes in the Dominican Republic.

Methods: Baseline and postoperative information from 156 of the mission's recipients of hip and knee TJA was used. Demographics were abstracted from clinical notes and self-reported pain and functional status were assessed using WOMAC and SF-36 measures. Bivariate analysis identified variables to include in multivariable regression models of factors associated with function and pain outcomes and improvement in these domains one or two years postoperatively.

Results: The cohort had a mean age of 61.3, 82% were female, 79% had total knee arthroplasty, and 42% of procedures were bilateral. In multivariate analyses, at $p < 0.05$, male sex, better preoperative function, and use of bilateral procedure were associated with better functional outcome. Male sex and worse preoperative pain were associated with better pain outcome. Worse preoperative pain and function, as well as bilateral surgery were associated with greater

improvement in function. Additionally, a greater number of bothersome joints was associated with greater pain reduction.

Conclusion: Our findings of better follow-up pain scores among patients with worse pain preoperatively and better functional improvement among those undergoing bilateral replacements contrast with study results from developed countries. The explanations for these observations merit further study.

Keywords

Knee arthroplasty; Hip Arthroplasty; Patient Reported Outcomes; International; Predictors of outcome

Osteoarthritis (OA) is one of the leading causes of global disability, accounting for 17.1 million years of life lived with disability [1]. The prevalence of OA is on the rise in developing countries due to an increase in obesity, knee injury and longevity [2, 3]. In response to the growing burden of joint disease, developing countries are creating their own total joint arthroplasty (TJA) programs for patients with severe OA [4, 5], as TJA is a common and successful surgical intervention used in the developed world for pain relief and functional improvement in persons with OA [6, 7]. TJA produces symptomatic improvement in most patients; however up to 30% of patients report suboptimal improvement [8–10]. Research that seeks to identify which patients are more or less likely to succeed is particularly important in developing countries that have to determine how to best allocate their limited resources.

Substantial research in developed countries suggests that younger age [11, 12], higher education level [8, 13], lower BMI [14, 15], fewer co-morbidities and affected joints [16, 17], better mental health status and more positive patient expectations [18, 19], as well as lower baseline functional impairment and pain levels [12, 16, 20] have been associated with better patient-reported pain and functional outcomes. While these findings can be used to guide TJA recommendations in the developed world, in light of sociocultural influences on disease and illness [21, 22], these trends should not be assumed to extend to other contexts. Previous research has indicated that that more work should be done to identify predictors of outcomes in disadvantaged nations, as functional outcome patterns have been shown to differ between developed and developing nations [23, 24]. To date, there has been no prior research on predictors of TJA outcomes in a developing country that has adjusted for potential confounders.

This investigation uses data collected by a short-term medical mission to the Dominican Republic (DR) to identify predictors of follow-up function and pain, as well as the extent of improvement in functional status and pain. This information may help clinicians estimate the potential benefit of surgery for individuals in developing countries.

Patients and Methods:

Setting:

The Dominican Republic shares the Caribbean island of Hispaniola with Haiti and has a population of approximately 10.5 million people, 41% of whom live below the national poverty line. The Dominican economy has a per capita gross national income of \$13,570, or approximately 24% of that in the US [25]. The Dominican public health care system provides basic healthcare coverage to all citizens, but advanced treatments such as TJAs are not covered. Therefore, only a small number of Dominicans with additional insurance are able to receive these elective surgeries.

Operation Walk Boston (Op-Walk Boston) is a philanthropic program that has provided free TJAs to over 300 economically disadvantaged patients since 2008 through its yearly trips to the Dominican Republic. A fifty-person team consisting of surgeons, anesthesiologists, medical internists, residents, students, physical therapists, nurses and operating room staff volunteer their time for the duration of the trip. American surgeons, following standardized protocols, perform the procedures with the assistance of Dominican surgeons. Patients initiate physical therapy with American physical therapists during the mission and are then scheduled for continued care with staff at the host institution.

Subjects:

All surgical patients who received treatment from 2009–2013, who had a pre-operative assessment and returned for a follow-up evaluation at one or two years after surgery were eligible for this study. The sample included recipients of both total hip and total knee arthroplasty. Study procedures were approved by the institutional review boards at both the American and Dominican hospital.

Data Collection:

Research associates collected information on Op-Walk Boston patients by administering surveys to consenting pre-operative patients and to patients when they returned for scheduled yearly follow-up appointments. All surveys were written in Spanish and were adapted from prior publications [26]. Research associates helped patients read and understand the survey when needed. In addition, research associates abstracted select baseline data from medical records.

The following predictors were collected from patient medical records: age, sex, cigarette and alcohol use, body mass index (BMI), number of co-morbidities, arthritis type, joint replaced, and whether a unilateral or bilateral procedure was performed.

A pre-operative questionnaire queried about demographic details and how optimistic patients were about the TJA (expectations for pain improvement, and probability of complications during surgery). Both pre-and post-operative surveys incorporated Spanish versions [26, 27] of the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) [28], as well as the Mental Health subscales of the Short-Form 36 (SF-36) [29]. The scores from the WOMAC and SF-36 forms were transformed to a 0–100 point scale

(100 worst). Previous studies have reported the high internal consistency of these subscales within the Dominican cohort, demonstrating a Cronbach's alpha coefficient of 0.79 and 0.95 for pre-operative WOMAC pain and function respectively, as well as 0.75 for the SF-36 mental health scale. These exceed the commonly accepted threshold for internal consistency of 0.7 [30].

Continuous variables were categorized as follows: age was categorized as ≥ 65 years at time of surgery vs < 65 ; education was divided into less than high school and a high school diploma or higher; BMI was separated into three groups: normal and overweight (< 30), class I obese (> 30 – 34.9), and class II+ obese (≥ 35); and number of comorbidities was classified as 0, 1, and 2+. We created a variable (joint burden) to capture the number of painful lower extremity joints (hips and knees). A joint was considered symptomatic if the patient reported at least a moderate level of pain in that joint. Patients were classified as having either 1 symptomatic joint or 2+ if they indicated that they had more than moderate pain in two or more joints [31]. To determine the predictive value of baseline WOMAC pain and function, patients were divided into tertiles based on their preoperative scores for both measures. Additionally, to assess how preoperative optimism influenced outcomes we created a variable based on patients' preoperative expectations about post-surgical pain relief and complications. Patients were stratified into two groups: "most optimistic" for patients that believed they had a $> 90\%$ probability of pain relief and a $< 1\%$ chance of a severe surgical complication, and "less optimistic" for whose expectations regarding either pain relief or complications were less sanguine (i.e., $< 90\%$ probability of pain relief or $> 1\%$ chance of a severe surgical complication).

Statistical Analysis:

Post-operative outcomes included one-year or two-year follow-up WOMAC pain and function scores, as well as change in these scores from baseline to follow-up. To identify which variables to include in the predictive models we first conducted bivariate analyses (Table 2) examining the association between each predictor and outcome. We then advanced those variables that had a p-value less than 0.15 and/or a difference in WOMAC score of at least six points across categories of the predictor variable to multivariate linear regression models. We kept predictors with a p-value of less than 0.1 in the final models.

The follow-up WOMAC pain and WOMAC function scores had skewed distributions, with a preponderance of patients reporting excellent results. Consequently, we also performed linear regressions that used the square root of the WOMAC Pain and Function scores at follow up as the outcome variable. As results were more conservative with the square root transformation, we used this analysis as the primary outcome. Pain and function improvement were found to be normally distributed.

We calculated power to detect effects of binary covariates on continuous pain and function outcomes in 156 patients with complete pre-and postoperative data. We assume Type I error of 0.05 and an equal distribution of patients with and without a covariate of interest (eg age < 65 vs. ≥ 65). Under these circumstances we have power of 0.8 to detect differences in outcome of 0.45 standard deviations and power of 0.87 to detect differences in outcome of

0.5 standard deviations. Power is generally increased in multivariate analyses, which reduce error variance. Thus, the analysis has adequate power to detect moderately strong effects.

Results:

Patient pre-operative demographics:

Of 194 patients operated upon between 2009 and 2013, 156 patients had a pre-operative evaluation and a follow-up evaluation between 2010 and 2014. Characteristics of the participants are shown in Table 1. Patients were between 18 and 81 years of age (mean age 61.3 years). The majority of patients were females (82%), and the majority received knee replacements (79%). Most patients had OA (80%), two or more troublesome joints (64%), and underwent unilateral TJA (58%). Only 6% and 16% reported smoking cigarettes or drinking alcohol respectively. 78% of patients had a least one comorbidity and 37% were obese. Most patients (65%) felt that they had a greater than 90% chance for surgical success and a <1% chance of a severe surgical complication and thus were classified as “optimistic.” Additionally, the mean $\pm$ SD SF-36 mental health subscale score for all patients was 77.0 $\pm$ 18.2. Mean $\pm$ SD WOMAC pain and function scores were 59.1 $\pm$ 24.6 and 62.4 $\pm$ 24.5 (out of 100, higher value is worse) respectively.

Of the 38 patients not included in this cohort, 33 did not return for a follow-up evaluation and five did not have complete preoperative data. These patients had similar baseline characteristics. They had a mean age of 58.5 years, 72% were female, 70% received a unilateral TJA, and mean $\pm$ SD WOMAC pain and function scores were 53.2 $\pm$ 21.1 and 65.5 $\pm$ 20.9 respectively.

Changes in joint pain and functional impairment after TJA:

Mean $\pm$ SD of improvement in WOMAC pain and function after surgery were 43.0 $\pm$ 31.7 and 47.7 $\pm$ 27.1. Mean $\pm$ SD follow-up WOMAC pain and function were 15.9 $\pm$ 18.3 and 14.6 $\pm$ 14.5 respectively. 43 patients reported complete relief with a follow-up WOMAC pain or function score of 0. Eighty-eight percent of patients reported being satisfied with their surgical outcome. We did not observe significant differences in follow-up and improvement outcomes between patients who underwent knee vs hip replacement ($p=0.2$). Therefore, patients who underwent either knee or hip procedures remained in the same cohort.

Predictors of outcome:

Follow-up Functional Status: Bivariate analysis (Table 2) identified the following associations with better follow-up functional status: male sex, alcohol & cigarette use, OA diagnosis, bilateral procedure, higher optimism, better mental health, and better pre-operative function. These factors were then included in a multivariate analysis.

Four of the eight factors identified in the bivariate analysis stayed in the final transformed square root models and were found significantly associated with follow-up function in a multivariate analysis (Table 3). Older age was associated with worse (higher) function scores, with a transformed estimate of 0.08 points per ten years. Males, on average, had a follow-up function score that was 1.43 (0.16, 3.99) points better (lower) than females.

Additionally, patients who underwent bilateral TJA rather than unilateral procedures had a 1.09 (0.15, 2.89) point better follow-up function level. Finally, patients who had the best baseline function also had higher follow-up function, with a 0.66 (0.0008, 2.56) point difference in WOMAC score compared to patients in the lowest function tertile. This model explained 19.7% of the variance in outcome (R-squared 0.197).

Follow-up Pain: Bivariate analysis (Table 2) identified the following associations with better follow-up pain: male sex, OA diagnosis, better pre-operative function, and worst pre-operative pain. Three of these four factors remained in the final model and were found significantly associated with better follow-up pain when placed in a multivariate analysis (Table 3). Males, on average, had a follow-up pain score that was 1.50 (0.03, 5.13) points lower than women. Additionally, patients with the best baseline function had a score that was 0.60 (−0.17, 3.84) better than those with the worst baseline function. Finally, patients who were in the highest tertile of preoperative pain had a 2.01 (0.02, 7.24) point lower follow-up pain level than those in the lowest tertile of pain. This model explained 11.9% of the variance in outcome.

Functional and Pain Improvement: Bivariate analysis (Table 2) identified the following variables as associated with both greater functional and pain improvement: bilateral procedure, greater joint burden, worse preoperative function and preoperative pain.

The functional improvement multivariate model demonstrated that three of the factors identified through bivariate analysis were significantly associated with greater improvement (Table 4). Preoperative function contributed the most (38.31 points (29.10, 47.52)) to improvement, with those with the worst initial function improving the most. The second determinant was preoperative pain, with those with the highest level of preoperative pain improving the most (10.56 points (0.84, 20.27)). Additionally, patients with bilateral procedures (8.69 points (2.39, 14.99)) improved more. This model explained 60.9% of the variance in outcome.

The pain improvement multivariate model indicated that two of four factors identified through the bivariate analysis were significantly associated with greater improvement (Table 4). The level of preoperative pain was the largest determinant (58.32 points, (49.13, 67.51)) of improvement, with those who had the worst preoperative pain improving the most. Additionally, the model included the number of troublesome joints (those with more painful joints improved by 8.77 (1.33, 16.21) points more). These two factors explained 62.5% of the variance in the outcome.

We did not observe any of the following variables to be associated with any of the outcomes: age, education level, BMI, number of co-morbidities, type of arthritis, alcohol or cigarette use, whether a total hip or knee replacement was performed, mental health status or optimism.

Discussion:

To our knowledge this is the most comprehensive published assessment of the predictors of TJA outcomes in a developing nation. Using patient reported outcomes from patients undergoing TJA in the Dominican Republic we investigated preoperative variables associated with follow-up pain and function scores, as well as improvement in pain and function. Baseline scores were the strongest predictors of follow-up scores for both WOMAC pain and function. Additionally, the use of a bilateral procedure was associated with a better functional outcome and functional improvement.

For both pain and function, based on the beta coefficient the strongest predictors of improvement were baseline scores – the more impaired a patient is before surgery the greater the overall improvement. For functional improvement, both baseline pain and baseline function were associated with improvement, with subjects with the best pre-op function and best pre-op pain scores improving the least. For pain improvement, baseline pain but not baseline function was associated with improvement.

Follow-up pain and function models demonstrated predictors that were consistent with the literature from developed countries. However, there were striking differences as well. The association between male sex [12], better baseline functional status [12, 16, 20] with better follow-up outcome has been established in previous literature. One of our predictors of better follow-up function, whether a patient was undergoing a bilateral or unilateral procedure, has not been investigated in other published predictive models. Our finding that having a bilateral procedure was associated with better follow-up function, may indicate that in this population those who had unilateral surgery may have had unaddressed joint disease in their contralateral side. However, bilateral surgery was done only when both joints met all surgical criteria.

The relationship between male sex [32] and follow-up pain level has been documented in previous literature. However, our models additionally showed that worst preoperative pain was predictive of better follow-up pain (Fig 2), a finding that contradicts prior reports [33, 34]. It is expected that the patients in the worst preoperative pain tertile would report marked pain improvements, however previous literature has shown that they do not catch up to those with the lowest preoperative pain [33, 34]. Our data suggests that the most impaired patients in this cohort not only improve the most following TJA but actually have better follow up results.

Improvement models delineated similar predictors to those seen in the literature. Those with worst preoperative function and pain have more to gain and thus improve more than others [12, 33, 34]. Additionally, bilateral procedures were predictive of better functional improvement even after adjusting for their lower than average baseline scores. Furthermore, the pain improvement model indicated that while the number of painful joints preoperatively was not predictive of follow-up outcomes, it was predictive of improvement. Patients who have multi-joint involvement may not be able to participate as intensely in physical therapy as those with no other pain, leading to an impaired ability to improve.

Predictors that have been identified in developed countries, such as age[11, 12], education level [8, 13], BMI [14, 15], OA diagnosis[16, 35], the number of co-morbidities [16, 17], optimism[18, 19] and mental health score[18] were not predictive of any outcomes in our cohort. Education level may not be predictive because the distribution of educational attainment in the DR may not be as broad as in developed countries due to fewer educational opportunities. Additionally, Op-Walk Boston is targeted towards patients of lower socioeconomic status. However, the difference in the predictive value of medical variables, such as BMI and of co-morbidities, may be of particular importance for physicians working with this population.

Overall our analysis showed that of the predictors of follow-up function and pain found in the literature only baseline function and pain, as well as sex, were seen in the cohort of Dominican patients. All other factors that have been described in studies from high income countries were not significant predictors of outcome in this investigation. There may be several reasons for this including country specific differences in the distribution of social determinants of health such as education, and prevalence of health factors such as BMI and mental health status. These differences in the context of a distinct health care system and sociocultural beliefs may have led to the departure from the predictors of outcomes in high income countries.

The strengths of this study include the use of reliable, valid instruments for assessing outcomes of TJA, and the comprehensive list of preoperative variables. However, several limitations to this study should be noted. Our study is limited to patient outcomes from the Dominican Republic, and thus further work is needed to see if the reported patterns persist in other developing countries. Additionally, this analysis may not fully characterize the patient population as despite similar baseline characteristics there may be follow-up differences between the 156 patients in this cohort and the 38 with who were either lost to follow-up or had incomplete data. Also, the surgical expertise of the US staff that traveled to the DR may have produced results that do not align with those seen in developing countries. Furthermore, while statistically significant, variables with coefficients of less than 5.0 WOMAC points may not provide clinically relevant contributions to the predicted outcome score, since 5 points is regarded as less than a clinically relevant difference [36].

Conclusion:

Predictors of TJA outcomes in the Dominican Republic were similar but not identical to those seen in developed countries. In particular, higher preoperative pain and bilateral procedures are predictors of outcomes in the DR. As more developing countries expand their TJA services and surgical mission trips become more popular, there is a need to identify patient factors that are associated with a high likelihood of surgical success in order to inform current policies. Clinicians need to identify the pertinent predictors in their patient population as established patterns may not travel across borders. It would be beneficial if these organizations recorded and analyzed their outcomes to see whether the findings reported in our Dominican cohort are seen across the developing world.

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Figure 1.
Extent of improvement in WOMAC Function Score stratified by preoperative WOMAC function score. Standard error bars included.

Figure 2.
Extent of improvement in WOMAC Pain Score stratified by preoperative Pain function score
Pain Improvement. Standard error bars included.

Table 1.

Preoperative characteristics of Op-Walk Boston subjects

	Number	Percent
Age		
<65	82	54%
65	71	46%
Sex		
Male	28	18%
Female	128	82%
Education		
<HS	123	80%
HS	31	20%
BMI		
<30	94	64%
30–34.9	38	26%
35	16	11%
Substance Use		
Cigarette	9	6%
Alcohol	23	16%
Number of comorbidities		
0	35	22%
1	67	43%
2	54	35%
Principal joint diagnosis		
Osteoarthritis	125	80%
Rheumatoid Arthritis	31	20%
Joint		
Hip	33	21%
Knee	123	79%
Procedure		
Unilateral	90	58%
Bilateral	64	42%
Number of troublesome joints		
1	56	36%
2	100	64%
Optimism		
Most Optimistic	95	65%
Less Optimistic	51	35%
Preoperative Scores	Mean (SD)	
WOMAC Pain	59.07 (24.6)	
WOMAC Function	62.39 (24.53)	
SF-36 mental health	76.95 (18.24)	

BMI: Body Mass Index; WOMAC: Western Ontario and McMaster University Osteoarthritis Index; SF-36: Short-Form 36

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Table 2.

Bivariate analysis of association between preoperative factor and patient-reported outcomes.

Predictor Variable	Follow-up Pain		Follow-up Function		Pain Improvement		Functional Improvement	
	Mean	P	Mean	P	Mean	P	Mean	P
Age		0.52		0.20		0.86		0.41
<65	14.9		13.0		43.1		50.2	
>65	16.9		16.1		44.1		46.6	
Sex		0.02		0.0008		0.68		0.50
Male	8.7		6.4		40.6		44.5	
Female	17.5		16.4		43.5		48.3	
Education		0.30		0.79		0.11		0.42
Less than HS	15.1		14.8		45.0		48.2	
HS or greater	18.9		14.0		34.5		43.8	
BMI		0.69		0.43		0.16		0.23
<30	17.1		14.1		38.4		44.0	
30–34.9	14.1		15.2		50.2		52.8	
>35	17.3		19.3		41.8		48.7	
Substance Use		0.44		0.03		0.22		0.15
No Alcohol	16.5		15.7		44.5		49.3	
Alcohol	13.3		8.6		35.2		40.3	
Cigarette Use		0.21		0.09		0.35		0.43
Smoker	8.3		6.5		33.3		40.6	
Non-smoker	16.2		15.1		43.7		47.9	
Number of comorbidities		0.9		0.19		0.43		0.53
0	15.0		11.1		40.6		47.8	
1	15.7		14.7		40.5		45.1	
>2	16.7		16.8		47.7		50.7	
Main Diagnosis		0.03		0.03		0.44		0.53
Osteoarthritis Rheumatoid	14.3		13.3		44.0		48.3	
Arthritis	22.3		19.8		39.1		44.9	
Joint		0.19		0.19		0.87		0.69
Hip	12.2		11.6		41.7		45.7	
Knee	17.0		15.4		42.8		47.8	
Procedure		0.27		0.07		<.0001		<.0001
Unilateral	17.3		16.4		33.9		37.8	

Predictor Variable		Follow-up Pain	Follow-up Function	Pain Improvement	Functional Improvement
	Bilateral	14.0	12.1	54.7	61.1
Number of troublesome joints		0.18	0.82	<.0001	<.0001
	1	18.6	14.3	23.8	32.1
	2	14.4	14.8	54.2	56.5
Perception of Total Joint					
Replacement		0.15	0.02	0.43	0.37
Most Optimistic		13.9	12.1	44.6	49.9
Least Optimistic		18.5	17.8	40.2	45.5
WOMAC Pain		0.11	0.56	<.0001	<.0001
Least Pre-Op Pain		17.2	13.1	15.9	28.8
Medium Pre-Op Pain		18.2	15.9	47.8	52.9
Worst Pre-Op Pain		10.3	15.3	79.1	70
WOMAC Function		0.06	0.13	<.0001	<.0001
Best Pre-Op Function		12.7	11.6	24.8	23.4
Medium Pre-Op Function		21.1	16.9	41.4	50.1
Worst Pre-Op Function		15.0	16.0	63.5	71.6
SF-36 mental health		0.46	0.004	0.31	0.60
Best Mental Health		15.3	12.8	41.5	47.0
Worst Mental Health		17.8	20.5	47.9	49.7

Bolded values: Variables with p-value < 0.15 were included in final models WOMAC and SF-36 forms were transformed to a 0–100 point scale (100 worst) BMI: Body Mass Index; WOMAC: Western Ontario and McMaster University Osteoarthritis Index; SF-36: Short-Form 36

Table 3.

Multivariate linear models of predictors of follow-up function and pain.

Predictor Variable	Function (Estimate, 95% CI)	Transformed Estimate	Pain (Estimate, 95% CI)	Transformed Estimate
Intercept	1.22 (-0.49, 2.93)	1.49 (-0.24, 8.60)	2.51 (1.70, 3.31)	6.28 (2.89, 10.98)
Male	-1.20 (-2.00, -0.40)	-1.43 (-3.99, -0.16)	-1.23 (-2.27, -0.18)	-1.50 (-5.13, -0.03)
Female	Reference		Reference	
Age	0.03 (0.004, 0.05)	0.0008 (0.000017, 0.003)		
Best Pre-Op Function	-0.81 (-1.60, -0.03)	-0.66 (-2.56, -0.0008)	-0.77 (-1.96, 0.42)	-0.60 (-3.84, 0.17)
Moderate Pre-Op Function	0.38 (-0.39, 1.15)	0.15 (-0.15, 1.32)	0.55 (-0.49, 1.59)	0.31 (-0.24, 2.53)
Worst Pre-Op Function	Reference		Reference	
Best Pre-Op Pain			1.42 (0.14, 2.69)	2.01 (0.02, 7.24)
Moderate Pre-Op Pain			1.22 (0.15, 2.29)	1.50 (0.02, 5.27)
Worst Pre-Op Pain			Reference	
Unilateral	1.05 (0.39, 1.70)	1.09 (0.15, 2.89)		
Bilateral	Reference			

Pain and Function estimates are based on linear regressions that used the square root of the respective WOMAC scores at follow up as the outcome variable. Transformed estimate is the square of the corresponding value. WOMAC scores transformed to a 0–100 point scale (100 worst). Negative values indicate better outcome than corresponding reference value.

Table 4.

Multivariate linear models of predictors of improvement in function and pain.

Predictor Variable	Function Change (Estimate, 95% CI)	Pain Change (Estimate, 95% CI)
Intercept	77.26 (70.86, 83.66)	79.86 (73.38, 86.34)
Best	-38.31	
Pre-Op Function	(-47.52, -29.10)	
Moderate	-17.99	
Pre-Op Function	(-25.85, -10.12)	
Worst Pre-Op Function	Reference	
Best	-10.56	-58.32
Pre-Op Pain	(-20.27, -0.84)	(-67.51, -49.13)
Moderate	-3.14	-29.65
Pre-Op Pain	(-11.29, 5.02)	(-38.07, -21.24)
Worst Pre-Op Pain	Reference	Reference
One painful joint		-8.77 (-16.21, -1.33)
2 painful joints		Reference
Unilateral	-8.69 (-14.99, -2.39)	
Bilateral	Reference	

WOMAC Pain and Function forms were transformed to a 0–100 point scale. Baseline values were subtracted from follow-up values to demonstrate improvement. Negative values indicate less improvement than their reference counterpart.