3-30-2017

Differential burden of musculoskeletal pain in African Americans and whites patients at the time of total joint replacement surgery

Leslie R. Harrold
University of Massachusetts Medical School

Anthony Porter
University of Massachusetts Medical School

Philip C. Noble
Baylor College of Medicine

See next page for additional authors

Differential burden of musculoskeletal pain in African Americans and whites patients at the time of total joint replacement surgery

Authors
Leslie R. Harrold, Anthony Porter, Philip C. Noble, David C. Ayers, Jeroan J. Allison, and Patricia D. Franklin

Keywords
total joint replacement (TJR), musculoskeletal pain, rehabilitation, African Americans, Whites, health disparities

Comments
This article is a preprint and has not been peer-reviewed.

This work is funded in part by a grant (P50HS018910) from the Agency for Healthcare Research and Quality and by a grant from the Gladden Society.

Differential burden of musculoskeletal pain in African Americans and whites patients at the time of total joint replacement surgery

Anthony Porter MD[1]
Leslie R. Harrold MD MPH[1]
Philip C. Noble PhD[3]
David Ayers MD[1]
Patricia Franklin MD MBA MPH[1]
Jeroan Allison MD MS[2]

University of Massachusetts Medical School, [1]Department of Orthopedics and Physical Rehabilitation, [2]Department of Quantitative Health Sciences; [3]Baylor College of Medicine

Corresponding Author: Patricia D Franklin
University of Massachusetts Medical School
Department of Orthopedics and Physical Rehabilitation
University of Massachusetts Medical School
55 Lake Avenue North, Worcester, MA01655 USA
(508) 856 5748– telephone
(508) 856-2581 – fax
Patricia.Franklin@umassmed.edu

This work is funded in part by a grant (P50HS018910) from the Agency for Healthcare Research and Quality and by a grant from the Gladden Society.

Acknowledgements: The authors gratefully acknowledge the 140 surgeons who participate in the FORCE-TJR national consortium, especially the core site PIs, Courtland Lewis MD, Regis O'Keefe MD PhD, and Vincent Pellegrini MD. We also appreciate the editorial assistance of Sylvie Puig, PhD.

ABSTRACT

Objective: African Americans patients have greater operative joint pain and functional limitation at the time of total joint replacement (TJR) compared to white patients. We examined the factors associated with this apparent disparity.

Methods: A consecutive sample of 5745 patients with advanced knee and hip osteoarthritis [who elected to undergo TJR in 2011-201] reported, preoperatively, medical comorbidities, operative and non-operative hip/ knee pain using Hip and Knee Disability and Osteoarthritis Outcome Scores (HOOS/KOOS), function using Short Form 36 Physical Component Score (PCS). Total burden of musculoskeletal pain was quantified as moderate/severe pain in non-operative hip and knee joints and lumbar back pain using Oswestry Disability Index (ODI). Associations among race, medical co-morbidites (modified Charlson), total musculoskeletal pain burden, operative joint pain, and functional limitations were examined using multivariable regression models.

Results: Compared to Whites, African Americans (143 hips and 201 knees) reported worse surgical joint pain (mean pain: 39.3 vs. 49.2 [hip]; 43.4 vs. 53.2 [knee]), poorer surgical joint function (mean function: 38.9 vs. 45.7 [hip]; 45.9 vs. 53.4 [knee]), poorer global function (mean PCS: 30.0 vs. 31.6 [hip]; 31.3 vs. 33.1 [knee]), and more non-operative joints pain ($p<0.03$). In adjusted multivariable models, differences at the time of surgery were explained in large part by differences in musculoskeletal pain in the hips, knees, and low back.

Conclusions: Greater burden of musculoskeletal pain explains differences in pre-operative pain and function between African American and white patients and likely impacts rehabilitation and subsequent TJR outcomes.

INTRODUCTION

Osteoarthritis is the leading cause of degenerative joint disease leading to disability among U. S. adults.(1) As there is no known cure for this disease, end-stage degeneration is commonly treated with total joint arthroplasty, typically consisting of total knee (TKR) or total hip (THR) replacement. These operations are the most commonly performed and the most cost-effective surgical procedures in the US today, and have proven highly successful in eliminating the pain associated with advanced osteoarthritis unresponsive to medical treatement. (2) Increases in the demand for TKR and THR is predicted to lead to 3.48 million TKR procedures and 572,000 THR procedures being performed annually by 2030. (3)

Despite the proliferation of Total Joint Replacement (TJR) surgery, regional and ethnic disparities exist in the utilization of these procedures (4,5,6) and African American patients, in particular, undergo TJR at lower rates than white patients and with more severe pre-operative symptoms and functional deficits as compared to white patients. (7) The reasons for these differences are still not well understood and are multifactorial, and include longer delays in seeking or receiving definitive orthopedic care, either due to barriers within the health-care system or reluctance of patients to obtain treatment (8). More research is needed to address these disparities.

Our recent research has defined the effect of total pre-operative musculoskeletal conditions on pain and function, both before and after TKR. In particular, we reported that poorer patient function (SF-36 PCS score) prior to TKR was associated with the presence of moderate to severe pain in greater numbers of weight-bearing locations (operatively treated knee, non-operatively treated knee, ipsilateral hip, and low back).(9) In the present study, we sought to examine whether greater pre-operative pain and poorer function in African American patients

compared to white patients were influenced by differences in burden of musculoskeletal pain in a cohort of patients derived from a total joint replacement registry, which has enrolled more than 15,000 patients from 140 orthopedic surgeons across 22 states in the US.

PATIENTS & METHODS

Design Overview

Data sources

Under Institutional Review Board (IRB) approval, primary TJR patients are enrolled from 140 orthopedic practices having a diverse range of surgical volumes and geographic locations encompassing 22 states within the United States.(10) These practice settings were selected to provide a balanced representation of a diverse range of orthopedic practices in terms of urban and rural locations, and joint replacement patients as reflected by average community income. Surgeons participating in this cohort enroll their patients who then submit their own outcomes data through completion of validated outcome instruments, with a pre-operative completion rate in excess of 95%. Patients provide informed consent before enrollment as well as informed consent for the surgical procedure.

Setting and Participants

The first 2,439 primary THR (143 African American and 2296 white) patients and 3,306 primary TKR (201 African American and 3105 white) patients were included in the analysis. All were treated by 111 orthopaedic surgeons and underwent surgery between 7/1/2011 to 3/8/2013 for treatment of osteoarthritis. Exclusion criteria included diagnoses other than osteoarthritis (Rheumatoid Arthritis, Avascular Necrosis), prior joint replacement surgery or other surgical implants in the operative joint, or joint replacement due to acute fracture or cancer.

Measures and Data Collection

Baseline data were collected from patients at the time that TKR or THR was scheduled and patients were enrolled into the study. Patient demographic and clinical characteristics included age, gender, race, marital status, education, insurance, household income, smoking status, body mass index (BMI), and medical co-morbidities to calculate the modified Charlson co-morbidity index.

Pre-operative joint pain and function was measured using the Hip and Knee Disability and Osteoarthritis Outcome Scores (HOOS/KOOS) and used to esitmate the WOMAC pain and function sub-scores. Global function was evaluated with the Short Form 36 (SF-36) Physical Component Score (PCS), and emotional health was examined using the SF-36 Mental Component Score (MCS). Musculoskeletal pain in the non-operative lower extremity hip and knee joints was assessed using the HOOS/KOOS pain items and lumbar spine pain using the Oswestry Disability Index (ODI). The number of non-operative hip and knee joints (range 0-3) with moderate to severe pain was calculated.

Statistical Analysis

Demographic data and clinical characteristics were compared between African American and white patients who underwent THR and TKR. Differences between continuous variables were evaluated with Student's t-tests, while chi-square tests were evaluated for categorical variables. Multivariable forward linear stepwise regression models were used to identify independent predictors of pre-operative pain and function. Three separate regression analyses were performed using 3 different pre-operative measures as the dependent variable: (i) the HOOS/KOOS function score, (ii) surgical knee (KOOS) or hip pain (HOOS), and (iii) the SF-36

PCS scores. The initial formulation of each model (Model 1) contained race/ethnicity alone. Then additional covariates were entered in a stepwise fashion as follows:

(i) demographics and economic status (Model 2),

(ii) BMI, marriage status, smoking status, insurance status, and baseline SF-36 MCS score (Model 3),

(iii) Charlson Co-Morbidity Index (Model 4), and finally

(iv) Oswestry Disability Index score and the number of non-operative hip and knee joints with moderate to severe pain (Model 5).

Backwards stepwise linear regression models using the same variables were performed to confirm the statistical significance of the independent variables identified in the forward regression analyses. The threshold for significance was set at 0.05 or lower for all tests.

RESULTS

Demographic and baseline scores

When compared to white TJR patients, African American patients were younger, more often female, and more obese, had a higher prevalence of medical co-morbidities and were more likely to smoke at the time of surgery. African American patients also reported higher baseline HOOS/KOOS scores for pain within the operative joint (THR: 39.3 vs. 49.2, $p<0.001$; TKR: 43.4 vs. 53.2, $p<0.001$) , greater impairment of function (THR: HOOS 38.9 vs. 45.7, $p<0.001$; TKR: KOOS 45.9 vs. 53.4, $p<0.001$)**,** and poorer emotional health than white patients (**Table 1**). In addition, African Americans patients more frequently reported moderate-severe pain within the non-operative hip and knee joints as compared to white patients (THR: one additional joint 35.2% vs. 24.8%, two additional joints 13.4% vs. 5.7% and three additional joints 8.5% vs.

Table 1. Baseline patient characteristic data

	THR			TKR		
	White (N=2,296)	Black (N=143)	p value	White (N=3,105)	Black (N=201)	P value
Age (Mean ± SD)	64.7 ± 10.6	59.9 ± 12.2	<0.001	66.9 ± 9.3	62.0 ± 8.9	<0.001
Female (%)	57.4%	62.9%	0.194	60.8%	69.7%	0.013
BMI (Mean ± SD)	29.1 ± 5.6	31.7 ± 5.6	<0.001	31.3 ± 6.0	34.6 ± 6.2	<0.001
Smoking status (%)						
Current	6.9%	19.2%	<0.001	5.0%	8.6%	0.007
Past	43.8%	30.5%		42.0%	32.5%	
Never	49.4%	50.4%		53.0%	58.9%	
Charlson Co-morbidity Index (%)						
N = 0	62.5%	54.2%	0.002	57.1%	49.0%	<0.001
N = 1	16.5%	21.8%		18.1%	27.0%	
N = 2-5	6.9%	14.1%		9.2%	17.0%	
N ≥ 6	14.2%	9.9%		15.6%	7.0%	
Baseline SF-36 PCS (Mean ± SD)	31.6 ± 8.7	30.0 ± 8.7	0.0317	33.1 ± 8.3	31.3 ± 8.1	0.0031
Baseline SF-36 MCS (Mean ± SD)	50.9 ± 12.2	47.0 ± 13.1	0.0003	52.1 ± 11.8	47.4 ± 13.6	<0.001
WOMAC pain score of ipsilateral non-operative joint** (mean ± SD)	76.8 ± 24.4	66.8 ± 31.0	<0.001	88.9 ± 18.0	83.1 ± 22.9	<0.001
WOMAC pain score of contralateral non-operative joint** (mean ± SD)	90.7 ± 16.9	85.5 ± 22.2	0.0007	91.8 ± 15.6	86.5 ± 22.8	<0.001
WOMAC pain score of contralateral operative joint** (mean ± SD)	87.9 ± 19.7	75.7 ± 28.1	<0.001	79.5 ± 22.0	69.0 ± 25.6	<0.001
# of additional painful joints (%)						
0	66.5%	43.0%	<0.001	69.5%	51.2%	<0.001
1	24.8%	35.2%		23.6%	32.0%	
2	5.7%	13.4%		4.5%	12.2%	
3	3.0%	8.5%		2.4%	4.6%	
Baseline WOMAC of OPERATIVE joint**						
Pain (mean ± SD)	49.2 ± 19.4	39.3 ± 21.0	<0.001	53.2 ± 18.2	43.4 ± 20.3	<0.001

Stiffness (mean ± SD)	38.4 ± 21.6	34.2 ± 22.4	0.0265	44.4 ± 21.9	37.0 ± 23.3	<0.001
Function (mean ± SD)	45.7 ± 19.2	38.9 ± 19.6	0.0001	53.4 ± 18.1	45.9 ± 19.9	<0.001
Total score (mean ± SD)	45.8 ± 18.3	38.8 ± 18.7	<0.001	52.6 ± 17.1	44.8 ± 18.8	<0.001
** WOMAC values are based on HOOS for hips/KOOS for knees						

3.0%; TKR: one additional joint 32.0% vs. 23.6%, two additional joints 12.2% vs. 4.5% and three additional joints 4.6% vs. 2.4%; $p<0.001$ for all). More African American TKR patients also reported severe low-back pain: 20.0% vs. 10.5% ($p<0.003$).

Relationships among preoperative musculoskeletal pain, function, and race

In patients undergoing THR, race/ethnicity was significantly associated with HOOS pain and function in unadjusted models (Model 1; **Figure 1**). The coefficient for race/ethnicity was diminished in each subsequent model after the addition of sociodemographic, behavioral, medical comorbidity, and musculoskeletal co-morbidity (Models 2, 3, 4, 5; **Figure 1**). In the final model (Table 2), factors significantly associated with greater preoperative HOOS pain included female gender, younger age, greater BMI, poorer emotional health, greater low back pain and greater number of painful non-operative hip/knee joints. Similarly, the factors associated with worse preoperative HOOS function included female gender, greater BMI, being single, current smoker, worse emotional health, greater low back pain and greater number of non-operative hip/knee joints (**Table 2**). Coefficients associated with moderate or severe pain ranged from -3.9 to -8.1 (low back) and from -10.4 to -8.4 (one or two non-operative hips/knees), suggesting a strong negative relationship with functional outcome.

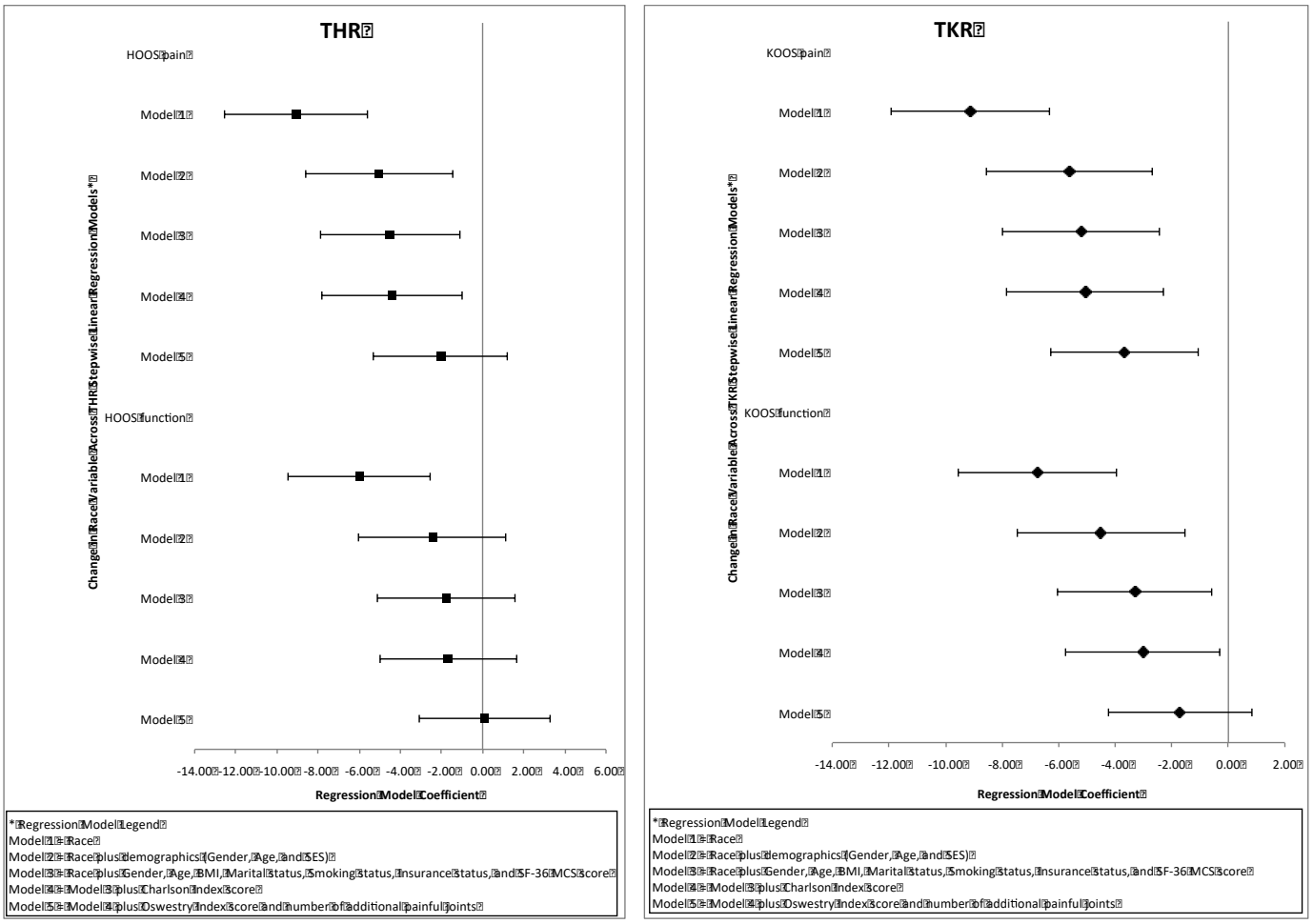
Table 2. Regression analysis results of final model for both THR and TKR*

TJR type	**THR**				**TKR**			
	HOOS pain		HOOS function		KOOS pain		KOOS function	
Variable	Coef	p value	Coef	p value	Coef	p value	Coef	p value
African American race/ethnicity	**-2.05**	**0.217**	**0.086**	**0.958**	**-3.68**	**0.006**	**-1.71**	**0.190**
Sociodemographic characteristics and medical comorbidity								
Female gender	**-3.64**	**<0.001**	**-3.03**	**<0.001**	**-3.47**	**<0.001**	**-3.33**	**<0.001**
Age	0.23	<0.001	-0.01	0.770	**0.18**	**<0.001**	**-0.082**	**0.039**
BMI	**-0.19**	**0.004**	**-0.39**	**<0.001**	**-0.14**	**0.007**	**-0.27**	**<0.001**
Married	**0.77**	**0.350**	**1.68**	**0.039**	-0.70	0.301	0.03	0.960
Nonsmoker	**3.11**	**0.030**	**3.91**	**0.005**	1.76	0.198	2.00	0.131
Pre-MCS score	**0.29**	**<0.001**	**0.37**	**<0.001**	**0.27**	**<0.001**	**0.34**	**<0.001**
Charlson 1	-0.93	0.358	-1.20	0.224	-0.13	0.872	-1.04	0.181
Charlson 2-5	-1.02	0.487	-0.36	0.802	**-0.68**	**0.518**	**-2.41**	**0.018**
Charlson 6	0.43	0.694	0.41	0.699	-0.26	0.757	-0.81	0.323
Musculoskeletal burden of pain								
Oswestry mild	-1.22	0.183	-0.75	0.400	-1.14	0.121	-1.03	0.146
Oswestry moderate	**-4.33**	**<0.001**	**-3.88**	**<0.001**	**-3.39**	**<0.001**	**-3.60**	**<0.001**
Oswestry severe	**-9.15**	**<0.001**	**-8.08**	**<0.001**	**-5.27**	**<0.001**	**-6.48**	**<0.001**
1 Non-operative painful hip/knee joint	**-9.59**	**<0.001**	**-10.39**	**<0.001**	**-11.41**	**<0.001**	**-10.87**	**<0.001**
2 Non-operative painful hip/knee joints	**-10.71**	**<0.001**	**-8.41**	**<0.001**	**-12.31**	**<0.001**	**-12.49**	**<0.001**
3 Non-operative painful hip/knee joints	**-17.02**	**<0.001**	**-15.91**	**<0.001**	**-18.64**	**<0.001**	**-19.64**	**<0.001**

*models included health insurance type and were not significant.

In patients undergoing TKR, race/ethnicity was significantly associated with pre-operative KOOS pain and function in the unadjusted analyses (Model 1; **Figure 1**). The addition of socio-demographic and behavioral factors, medical comorbidities, and the burden of musculoskeletal comorbidity reduced the coefficient associated with race/ethnicity (Models 2, 3, 4, 5; **Figure 1**). Race/ethnicity remained significantly associated with preoperative KOOS pain in the adjusted analyses (Table 3), but not in other models. Specifically, the factors associated with greater KOOS pain included African American race/ethnicity, female gender, younger age, increased BMI, worse emotional health, greater low back pain and greater number of painful non-operative hip/knee joints. The factors associated with worse KOOS function included female gender, increasing age, increased BMI, emotional health, the presence of 2 to 5 medical conditions, and greater number of painful non-operative hip/knee joints. The coefficients associated with moderate or severe pain ranged from -3.6 to -6.5 (low back) and -10.9 to -12.5 (one or two non-operative knees/hips), suggesting a strong negative relationship with functional outcome.

Figure 1. The impact of pre-surgical characteristics on the race/ethnicity coefficient in incremental THR and TKR multivariable models of joint pain and function.



DISCUSSION

In the comprehensive final multivariable model of data from this cohort, sociodemographic variables plus medical and musculoskeletal comorbidities eliminated or minimized the role African American race/ethnicity played in explaining greater pain and poorer function in pre-operative THR and TKR patients. Notably, the burden of musculoskeletal pain (i.e., patient-reported low back pain and moderate-severe pain in the non-operative hip and knee joints) was much greater in African American patients as compared to white patients. In addition,

African American patients were younger, more often obese, and had lower emotional health scores as compared to white patients at the time of TJR. To our knowledge, this is the first study to evaluate the substantial impact of musculoskeletal comorbid pain on preoperative symptoms in African American patients.

Our findings confirm those of others demonstrating racial disparities in the utilization of TJR, with African American patients presenting with greater baseline operative joint pain and functional impairment, compared to white patients, consistent with the presence of more advanced joint degeneration. (11) In contrast to prior analyses, we identified patient factors that influence pre-operative pain and function and their relative contributions to the poorer health status at the time of TJR. As can be seen in the final regression analyses, variables representing the burden of musculoskeletal disease had the largest coefficients in models explaining pain and function.

Musculoskeletal comorbidities are in general understudied. One possible reason is that ICD9 codes used in administrative data are generally limited to the presence or absence of joint conditions and do not capture the severity of pain or the number of affected joints. Thus, the severity of arthritic pain in the lumbar spine, hips, and knees are not included in administrative datasets. Our analyses suggest that if clinicians and researchers want to understand the variation in physical function and hip and knee pain it is important to add measures capturing the severity of musculoskeletal disease as manifest in each of the joints of the skeleton, and not simply the joint that is most symptomatic at the time of a clinical consultation.

There are several mechanisms by which arthritic pain in multiple weight-bearing joints may influence joint-specific function. For instance, pain in the low back or hips may alter biomechanics so that more weight is borne by the surgical joint. Patients may also limit their

activity due to the overall burden of musculoskeletal disease resulting in disuse and atrophy of the large muscle groups of the lower extremity. Together, these factors may increase dysfunction in the surgical joint.Regardless of the mechanism, arthritis in other joints will likely impact rehabilitation which is critical for optimal post-TJR outcomes.

Based on our findings, several recommendations can be made for physicians evaluating patients for referral to an orthopedic surgeon. First, physicians should proactively evaluate and monitor the total burden of arthritis in bilateral knees and hips as well as in the lumbar spine, particularly in the African American population. Given that an estimated 20 to 35% of patients referred for TKR and THR have generalized arthritis (12), pain in other joints of the lower extremities and the low back will be commonly present. In our cohort, moderate-severe pain was reported in one or more non-operative joints by 33.5% of TKR patients and 34.8% of THR patients. Another 28.0 % of knee replacement patients and 35.4% of hip replacement patients reported significant low back pain.

Second, the threshold and timing for referral of patients for orthopedic evaluation should be influenced by the total burden of musculoskeletal disease in order to optimize the outcomes of TJR surgery. Currently there are no standardized guidelines on when to refer arthritis patients for TJR. However, earlier referral for patients with substantial total musculoskeletal arthritis may allow the patient to engage more actively in post-operative recovery. In addition, the surgeons can provide non-operative care for all the joints and body areas affected by musculoskeletal disease.

The identification of the disproportionate influence of musculoskeletal pain in African American patients has important implications for patient counseling and timing of referral to orthopedic care. A recent report showed that arthritis pain in the ipsilateral lower extremity joint

is associated with poorer outcomes after TJR. (13) In TKR, our single site study demonstrated the negative impact of pain in non-operatively treated joints and lower back pain on post-operative pain and function. (21) In summary, poorer pre-operative function and pain in non-operative joints is associated with poorer post-operative function. Thus, patients referred with greater burden of musculoskeletal disease, including African Americans, are at risk for poorer outcomes. Patients should be counseled that functional gain following TJR is likely to be influenced by factors beyond a successful procedure in the single joint.

The strength of this study is that it uses data from a national sample of patients of all ages from diverse practices reflecting the US norm. However, despite the cohort size, African American patients represented only 6% of our sample. While low, this prevalence parallels national utilization of TJR by African American patients, who are up to 5 times less likely to receive TJR. (14) Additionally, our cohort only captures patients who undergo TJR surgery, and does not include patients who are offered THR or TKR surgery but decline, or patients who never see an orthopedist due to a lack of referral or a personal choice to not seek surgical treatment. In the future, larger samples of minority patients will allow validation of these findings.

In conclusion, we found that African American patients had a greater burden of musculoskeletal pain as compared to white patients and that musculoskeletal pain in the non-operative locations contributed to differences in pain and function at the time of TJR. Despite the effectiveness of TJR surgery in patients with advanced arthritis, more advanced pain and functional impairment at the time of surgery are associated with poorer post-operative improvement.(15) Thus, it is important to identify factors associated with greater pain and functional impairment before surgery. Understanding the different profiles of musculoskeletal

pain is important for physicians who must determine the timing of referral to an orthopedic surgeon. Based on these data, particular attention should be paid to the referral timing among African American patients.

References:

1. **Hootman JM, Helmick CG.** Projections of US prevalence of arthritis and associated activity limitations. Arthritis Rheum. 2006; 54(1):226-9. [PMID: 16385518]

2. **Losina E, Walensky RP, Kessler CL, Emrani PS, Reichmann WM, Wright EA, et al.** Cost-effectiveness of total knee arthroplasty in the United States: patient risk and hospital volume. Arch Intern Med. 2009; 169(12):1113,21; discussion 1121-2. [PMID: 19546411]

3. **Kurtz SM, Ong KL, Schmier J, Mowat F, Saleh K, Dybvik E, et al.** Future clinical and economic impact of revision total hip and knee arthroplasty. J Bone Joint Surg Am. 2007; 89 Suppl 3:144-51. [PMID: 17908880]

4. **Centers for Disease Control and Prevention (CDC).** Racial disparities in total knee replacement among Medicare enrollees--United States, 2000-2006. MMWR Morb Mortal Wkly Rep. 2009; 58(6):133-8. [PMID: 19229164]

5. **Lopez JP, Burant CJ, Siminoff LA, Kwoh CK, Ibrahim SA.** Patient perceptions of access to care and referrals to specialists: a comparison of African-American and white older patients with knee and hip osteoarthritis. J Natl Med Assoc. 2005; 97(5):667-73.

6. **Skinner J, Weinstein JN, Sporer SM, Wennberg JE.** Racial, ethnic, and geographic disparities in rates of knee arthroplasty among Medicare patients. N Engl J Med. 2003; 349(14):1350-9.

7. **Lavernia CJ, Lee D, Sierra RJ, Gomez-Marin O.** Race, ethnicity, insurance coverage, and preoperative status of hip and knee surgical patients. J Arthroplasty. 2004; 19(8):978-85. [PMID: 15586333]

8. **Ibrahim SA, Franklin PD.** Race and elective joint replacement: where a disparity meets patient preference. Am J Public Health. 2013; 103(4):583-4. [PMID: 23409914]

9. **Ayers DC, Li W, Oatis C, Rosal M, Franklin PD.** Patient Reported Outcomes After Total Knee Replacement Vary Based on Pre-operative Coexisting Disease in the Lumbar Spine and Other Non-operative Joints; The need for a Musculoskeletal Comorbidity Index. J Bone Joint Surg Am. 2013;

10. **Franklin PD, Allison JJ, Ayers DC.** Beyond joint implant registries: a patient-centered research consortium for comparative effectiveness in total joint replacement. JAMA. 2012; 308(12):1217-8. [PMID: 23011710]

11. **Hausmann LR, Mor M, Hanusa BH, Zickmund S, Cohen PZ, Grant R, et al.** The effect of patient race on total joint replacement recommendations and utilization in the orthopedic setting. J Gen Intern Med. 2010; 25(9):982-8. [PMID: 20509053]

12. **Gunther KP, Sturmer T, Sauerland S, Zeissig I, Sun Y, Kessler S, et al.** Prevalence of generalised osteoarthritis in patients with advanced hip and knee osteoarthritis: the Ulm Osteoarthritis Study. Ann Rheum Dis. 1998; 57(12):717-23. [PMID: 10070270]

13. **Singh JA, Lewallen DG.** Medical and psychological comorbidity predicts poor pain outcomes after total knee arthroplasty. Rheumatology (Oxford). 2013; [PMID: 23325037]

14. **Bolen J, Schieb L, Hootman JM, Helmick CG, Theis K, Murphy LB, et al.** Differences in the prevalence and severity of arthritis among racial/ethnic groups in the United States, National Health Interview Survey, 2002, 2003, and 2006. Prev Chronic Dis. 2010; 7(3):A64. [PMID: 20394703]

15. **Franklin PD, Li W, Ayers DC.** The Chitranjan Ranawat Award: functional outcome after total knee replacement varies with patient attributes. Clin Orthop Relat Res. 2008; 466(11):2597-604.