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Race/Ethnicity Moderates the Association Between Psychosocial Resilience and Movement-Evoked Pain in Knee Osteoarthritis

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Objective. Racial/ethnic disparities in pain are well-recognized, with non-Hispanic blacks (NHBs) experiencing greater pain severity and pain-related disability than non-Hispanic whites (NHWs). Although numerous risk factors are posited as contributors to these disparities, there is limited research addressing how resilience differentially influences pain and functioning across race/ethnicity. Therefore, this study examined associations between measures of psychosocial resilience, clinical pain, and functional performance among adults with knee osteoarthritis (OA), and assessed the moderating role of race/ethnicity on these relationships.

Methods. In a secondary analysis of the Understanding Pain and Limitations in Osteoarthritic Disease (UPLOAD-2) study, 201 individuals with knee OA (NHB = 105, NHW = 96) completed measures of resilience (ie, trait resilience, optimism, positive well-being, social support, positive affect) and clinical pain, as well as a performance-based measure assessing lower-extremity function and movement-evoked pain.

Results. Bivariate analyses showed that higher levels of psychosocial resilience were associated with lower clinical pain and disability and more optimal physical functioning. NHBs reported greater pain and disability, poorer lower-extremity function, and higher movement-evoked pain compared with NHWs; however, measures of psychosocial resilience were similar across race/ethnicity. In moderation analyses, higher optimism and positive well-being were protective against movement-evoked pain in NHBs, whereas higher levels of positive affect were associated with greater movement-evoked pain in NHWs.

Conclusion. Our findings underscore the importance of psychosocial resilience on OA-related pain and function and highlight the influence of race/ethnicity on the resilience-pain relationship. Treatments aimed at targeting resilience may help mitigate racial/ethnic disparities in pain.

INTRODUCTION

Osteoarthritis (OA) is the most prevalent joint disease and leading source of pain among adults, affecting more than 30 million individuals in the United States alone (1). Although OA can affect any diarthrodial joint in the body, the knee is the most frequently affected site (2), with approximately 14 million adults experiencing symptomatic knee OA and over half having advanced disease (3). In addition to being one of the principal causes of disability, knee OA is associated with lower psychological

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SIGNIFICANCE & INNOVATIONS

- In adults with knee osteoarthritis, higher levels of psychosocial resilience were associated with lower clinical pain, disability, and functional impairment.
- Non-Hispanic blacks reported greater pain and functional limitations than non-Hispanic whites despite similar ratings of psychosocial resilience.
- The associations between optimism, positive well-being, and positive affect with movement-evoked pain were differentially expressed across race/ethnicity, suggesting that positive psychosocial resources may contribute to racial/ethnic disparities in pain.

functioning, tremendous economic burden, and decreased quality of life (4–6).

Racial/ethnic disparities in pain and disability are widely reported as non-Hispanic blacks (NHBs) experience more frequent, severe, and disabling pain relative to non-Hispanic whites (NHWs) (7, 8). Moreover, several studies have found that NHBs report greater experimental pain sensitivity to a number of quantitative sensory testing methods when compared with NHWs (8, 9). These effects also extend to OA, as NHBs experience higher rates of symptomatic and radiographic OA (10, 11), report greater average pain severity, and have higher levels of disability than NHWs (7, 11–13).

Although numerous psychosocial and clinical risk factors are suggested to contribute to these differences (12, 14), there is limited understanding of how positive resilience factors influence racial/ethnic disparities in pain and functioning. Resilience is broadly defined as a dynamic process promoting adaptation to adversity or severe stress (4), and there is an emerging literature supporting the protective nature that resilience has on chronic pain. Though resilience can be studied as a unitary measure, it can also be quantified in terms of the positive psychosocial factors that comprise it (eg, positive affect, social support, and optimism, among others). The studies that have explored resilience processes in OA have found higher levels of optimism and social support to be associated with decreased clinical and experimental pain (13, 15), greater life satisfaction (16), as well as lower depressive symptoms (16) and pain catastrophizing (15). Positive affect (ie, pleasant mood or emotion) is shown to be a strong predictor of lower daily clinical pain (17) and buffers against weekly elevations in negative affect during periods of increased pain and stress (18). Furthermore, a recent report found that trait resilience interacts with optimism to predict enhanced pain inhibition in individuals with knee OA (19).

Although these findings are promising and suggest that positive psychological constructs have the ability to modulate pain and associated symptoms, relatively little is known regarding the extent to which race/ethnicity differentially influences the resilience-pain relationship. In the one study examining this, optimism was associated with greater endogenous pain inhibition in pain-free adults; however, the strength of the relationship between optimism and pain modulation did not differ across participant ethnicity (ie, NHBs, NHWs, Asian Americans) (20). To the best of our knowledge, no studies have yet examined these interrelationships among individuals with chronic pain. Given the extensive literature recognizing variations in social and economic stressors, as well as differential patterns of pain coping across racial/ethnic groups (21, 22), it is reasonable to speculate that protective resilience factors known to mitigate the adverse effects of pain could also vary as a function of race/ethnicity. Understanding these differences may be particularly critical in terms of optimizing current pain treatments and reducing racial disparities in pain.

The primary aim of this study was to examine the associations between measures of psychosocial resilience (ie, trait resilience, optimism, positive well-being, social support, positive affect), clinical pain, and functional performance among individuals with knee osteoarthritis. It was hypothesized that greater levels of psychosocial resilience would be associated with less clinical pain severity and higher functional performance. A secondary aim was to determine if race/ethnicity moderated the associations between resilience measures with self-reported pain and functioning. Given the absence of previous research in this area regarding resilience, no a priori hypotheses were made.

METHODS

Participants

This is a secondary data analysis of a larger, multisite (University of Florida, University of Alabama at Birmingham) study examining race/ethnic group differences in central pain processing among individuals with or at risk for knee OA (Understanding Pain and Limitations in Osteoarthritic Disease [UPLOAD-2]) (19). Individuals (N = 201) aged 45 and older who self-identified as non-Hispanic and "Black/African American" or "White/Caucasian/European" were recruited from the community via posted fliers, radio and print media announcements, orthopedic clinic recruitment, and word-of-mouth referral. All participants provided written informed consent and were compensated for their involvement.

Procedures

All procedures were approved by the University of Florida and University of Alabama Institutional Review Boards. Participants' eligibility for study inclusion was determined through a telephone screening. The following sociodemographic and physical health data were acquired as part of the screening: self-reported sex,

age, ethnic/racial identity, and a brief health history including symptoms of knee OA. Participants were included if they were between the ages of 45 and 85 years and screened positive for clinical knee OA (23). This screening questionnaire showed 87% sensitivity and 92% specificity for radiographically confirmed symptomatic knee OA (24). Given widespread variability in definitions of OA, we adopted this approach to be as inclusive as possible in recruitment, as our primary focus was on understanding factors associated with knee pain rather than OA pathophysiology itself. Moreover, because this study was designed to evaluate progression of OA-related symptoms, we wished to enroll a cohort with a broad range of OA characteristics, from very early signs to more advanced disease. Exclusion criteria included the following conditions: 1) prosthetic knee replacement or other clinically significant surgery to the arthritic knee; 2) heart disease, congestive heart failure, or history of acute myocardial infarction; 3) peripheral neuropathy; 4) systemic rheumatic disorders, including rheumatoid arthritis, systemic lupus erythematosus, and fibromyalgia; 5) chronic daily opioid use; or 6) hospitalization within the preceding year for psychiatric illness.

Participants who met the initial study inclusion criteria completed a health assessment session approximately 1 to 2 weeks later. During this session, health history was collected and a Short Physical Performance Battery (SPPB) test (25) was conducted. Height and weight were documented for measurement of body mass index (BMI). Furthermore, all individuals completed a bilateral knee joint evaluation by the study's rheumatologists or nurse practitioners and were classified as either having, or being at risk for, knee OA. After the health examination, participants completed questionnaires on self-reported knee pain symptoms and measures of resilience.

Measures

Brief Resilience Scale. The Brief Resilience Scale (BRS) (26) is a six-item questionnaire that examines the ability to bounce back and recover from stress. Each item ranges from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicative of greater psychological resilience. The BRS demonstrates good reliability and validity, with adequate internal consistency noted in the present sample (α = 0.81).

Life Orientation Test–Revised. As a measure of dispositional optimism, participants completed the Life Orientation Test–Revised (LOT-R), which consists of six items (including four filler items not included in the calculation) to assess generalized positive expectancies. Items were rated on a five-point scale ranging from 0 (strongly disagree) to 4 (strongly agree), with higher scores signifying greater optimism. The LOT-R has good internal validity, test-retest reliability, and convergent and discriminant validity (27). Internal consistency for the sample was adequate (α = 0.77).

Positive Affect and Well-Being–Short Form. The Neuro-QOL Positive Affect and Well-being (PAW) Short Form (28) is a nine-item questionnaire reflecting components of positive affect, life satisfaction, and an overall sense of purpose and meaning. Items are rated on a five-point scale ranging from 1 (never) to 5 (always), with a total score ranging from 9 to 45. The PAW demonstrates good reliability and validity, with excellent internal consistency observed in the current sample (α = 0.94).

Multidimensional Scale of Perceived Social Support. This 12-item questionnaire measures perceptions of perceived support from family, friends, and a significant other, with items rated on a 7-point scale ranging from 1 (very strongly disagree) to 7 (very strongly agree). The total score assessing global perceived social support was used in the current study. Consistent with this sample (α = 0.95), good internal consistency reliability and test-retest stability for the total scale and subscales have been found (29).

Positive and Negative Affect Schedule. Positive and negative affect are underlying dimensions of a broad set of emotional states characterized by pleasant and unpleasant moods or emotions, respectively. As a measurement of affect, participants completed the Positive and Negative Affect Schedule and indicated the frequency with which they generally experience 10 positive (ie, interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, active) and 10 negative (ie, distressed, upset, nervous, scared, hostile, irritable, ashamed, jittery, afraid, guilty) feelings (30). Items are rated on a five-point scale ranging from 1 (very slightly or not at all) to 5 (extremely) with a total subscale ranging from 10 to 50. It yields two scores, one for positive affect (PA) and one for negative affect (NA). Because our aim was to target positive psychological factors, only the PA subscale was used in the analysis. For the current study, the internal consistency estimate for PA was excellent (α = 0.90).

Graded Chronic Pain Scale. The seven-item Graded Chronic Pain Scale (GCPS) (31) was used to assess current, worst, and average knee pain during the past 6 months (characteristic pain intensity score), as well as the degree to which knee pain interfered with daily activities (disability score). Items were averaged and multiplied by 10 to generate index scores for pain intensity and disability, with higher scores indicating greater symptomatology. Cronbach's α for the GCPS was 0.91.

Short Physical Performance Battery. The Short Physical Performance Battery (SPPB) is comprised of three performance tests of lower-extremity function: standing balance, 4-m walking speed, and ability to rise from a chair. These tests have been standardized and are frequently utilized in older participants as assessments of lower-extremity function (25). Each measure is scored from 0 (worst performance) to 4 (best performance), and

Table 1. Demographic and clinical characteristics of participants across race/ethnicity

	Overall N = 201	NHB N = 105	NHW N = 96	
	M or N (SD or %)	M or N (SD or %)	M or N (SD or %)	*P*
Age (years)	57.9(7.7)	56.4(6.5)	59.6(8.5)	0.004
Sex				0.277
Female	123(61.2)	60(57.1)	63(65.6)	
Male	78(38.8)	45(42.9)	33(34.4)	
Race				
NHB	105(52.2)	...	...	
NHW	96(47.8)	...	...	
Income[a]				<0.001
<$20,000	86(42.8)	58(56.9)	28(29.5)	
$20,000-39,999	37(18.4)	23(22.5)	14(14.7)	
$40,000-59,999	31(15.4)	8(7.8)	23(24.2)	
$60,000-99,999	26(12.9)	10(9.8)	16(16.8)	
>$100,000	17(8.5)	3(2.9)	14(14.7)	
Education				0.002
Some high school	14(7.0)	12(11.4)	2(2.1)	
High school degree	86(42.8)	51(48.6)	35(36.5)	
Associates or Bachelors	72(35.8)	33(31.4)	39(40.6)	
Graduate/professional	29(14.4)	9(8.6)	20(20.8)	
Marital status[a]				0.001
Married	69(34.3)	24(23.3)	45(47.4)	
Not married	129(64.2)	79(76.7)	50(52.6)	
Employment				0.002
Employed	80(39.8)	42(40.0)	38(39.6)	
Not employed	72(35.8)	47(44.8)	25(26.0)	
Retired	49(24.4)	16(15.2)	33(34.4)	
Knee pain duration[a]				0.384
<1 year	26(12.9)	15(14.4)	11(11.7)	
1 to 5 years	79(39.3)	45(43.3)	34(36.2)	
>5 years	93(46.3)	44(42.3)	49(52.1)	
BMI (kg/m^2)	31.9(7.7)	33.0(7.9)	30.7(7.2)	0.036
Testing site				0.185
UF	132(65.7)	64(61.0)	68(70.8)	
UAB	69(34.3)	41(39.0)	28(29.2)	

Abbreviation: BMI, body mass index; NHB, non-Hispanic black; NHW, non-Hispanic white; UAB, University of Alabama at Birmingham; UF, University of Florida.
[a] Some data not reported.

a total score ranging from 0 to 12 is calculated. Immediately after each performance test, participants were asked to rate the overall knee pain they experienced on a scale from 0 (no knee pain) to 100 (most intense knee pain imaginable) (32) as a measurement of movement-evoked pain (33–35).

Data Analysis

All data were analyzed using SPSS 24.0 (IBM). Prior to data analysis, data were checked for normality, outliers, and missing values. Race/ethnicity differences in demographic and clinical characteristics were assessed using chi-square for dichotomous variables and independent samples *t*-tests for continuous variables. Pearson's correlations were conducted to examine associations between measures of resilience and pain outcomes, and group differences in these variables were tested using multivariate analysis of variance/covariance. Unadjusted and adjusted (controlling for sociodemographic covariates) models were analyzed for comparison. Hayes' PROCESS macro (36) was used to examine the potential moderating effect of race/ethnicity on the relationships between resilience measures (ie, trait resilience, optimism, positive well-being, social support, PA) and pain outcomes (ie, pain intensity, pain disability, functional performance, movement-evoked pain). This regression-based path-analytic modeling tool generates automatic mean centering and conditional effects in moderation models. Given race/ethnicity differences in age, income, education, marital status, employment, and BMI, as well as their association with clinical pain in prior research, these variables were included as covariates in the moderation analysis. Study site was also included as a covariate. To obtain effect size estimates, partial eta squared (η_p^2) and Cohen's f^2 were calculated from generalized linear model and linear regression (ie, moderation) analyses, respectively (η_p^2: small = 0.01, medium = 0.06, and large = 0.14; f^2: small = 0.02, medium = 0.15, and large = 0.35). Significance was set at $P < 0.05$ (two-tailed test).

RESULTS

Participant characteristics

Demographic and clinical characteristics of the sample are shown in Table 1. The majority of the participants were female, had an income less than $20,000, completed a high school degree or greater, not married, employed either full- or part-time, and experienced knee pain for more than 5 years. The mean age was 57.9 years, and the average BMI was 31.9 kg/m^2. Age, income, education, marital status, employment status, and BMI were significantly different between NHBs and NHWs.

Pearson correlations across clinical measures

Pearson correlations amongst measures of resilience, pain, and function are presented in Table 2. Although no significant

Table 2. Pearson product-moment correlations among clinical characteristics

	Trait resilience	Optimism	Positive well-being	Social support	Positive affect	GCPS pain	GCPS disability	SPPB function	SPPB pain
Trait resilience	...								
Optimism	0.46**	...							
Positive well-being	0.56**	0.57**	...						
Social support	0.32**	0.34**	0.43**	...					
Positive affect	0.49**	0.44**	0.64**	0.28**	...				
GCPS pain	−0.17*	−0.25**	−0.20**	−0.24**	−0.06	...			
GCPS disability	−0.20**	−0.28**	−0.23**	−0.21**	−0.13	0.72**	...		
SPPB function	0.23**	0.30**	0.22**	0.22**	0.18*	−0.26**	−0.41**	...	
SPPB pain	−0.17*	−0.22**	−0.16*	−0.22**	−0.09	0.61**	0.47**	−0.20**	...

Abbreviation: GCPS, Graded Chronic Pain Scale; SPPB, Short Physical Performance Battery.
Note: *$P < 0.05$, **$P < 0.01$.

relationships were found between PA and pain intensity (P = 0.40), pain disability (P = 0.08), and movement-evoked pain (P = 0.25), the overall pattern of results suggests that individuals higher in trait resilience, optimism, positive well-being, and social support exhibited lower levels of pain intensity, pain disability, and movement-evoked pain, as well as higher levels of physical functioning. Furthermore, all measures of resilience were significantly and positively correlated with one another (r = 0.28 to 0.64).

Race/ethnic differences in measures of psychosocial resilience and pain

Group comparisons across psychosocial resilience and pain outcomes are presented in Tables 3 and 4. Although there were no differences across race/ethnicity in resilience measures, significant differences emerged for measures of clinical pain and function. When compared with NHWs, black participants reported higher levels of pain intensity ($P < 0.001$), pain disability ($P < 0.001$), physical functioning (P = 0.01), and movement-evoked pain ($P < 0.001$). With the exception of physical functioning (P = 0.18), these effects remained after controlling for age, income, education, marital status, employment, BMI, and study site (all values $P < 0.01$).

Moderation Analysis

Adjusting for covariates, race/ethnicity was examined as a moderator of the relationship between psychosocial resilience

Table 3. Descriptive and inferential statistics for measures of psychosocial resilience

	Unadjusted				Adjusted			
	NHB N = 105	NHW N = 96	Comparison		NHB N = 105	NHW N = 96	Comparison	
Measures	M (SD)	M (SD)	F	η_p^2	M (SD)	M (SD)	F	η_p^2
Trait resilience (1-6)	3.7(0.7)	3.8(0.8)	0.14	0.00	3.8(0.7)	3.6(0.8)	2.03	0.01
Optimism (0-24)	17.1(4.5)	18.4(4.9)	3.21†	0.02	17.8(4.5)	17.6(4.9)	0.09	0.00
Positive well-being (9-45)	36.2(7.0)	36.4(6.9)	0.05	0.00	37.1(6.9)	35.4(6.9)	2.46	0.02
Social support (12-96)	62.1(20.2)	64.9(16.0)	1.04	0.01	63.7(20.3)	62.8(16.1)	0.10	0.00
Positive affect (10-50)	34.1(8.4)	34.9(7.4)	0.49	0.00	34.7(8.5)	34.1(7.3)	0.20	0.00

Note. †P = 0.07. Adjusted models controlled for age, income, education, marital status, employment, body mass index, and study site.
Abbreviation: NHB, non-Hispanic black; NHW, non-Hispanic white.

Table 4. Descriptive and inferential statistics for measures of pain and function

	Unadjusted				Adjusted			
	NHB N = 105	NHW N = 96	Comparison		NHB N = 105	NHW N = 96	Comparison	
	M (SD)	M (SD)	F	η_p^2	M (SD)	M (SD)	F	η_p^2
GCPS pain (0-100)	66.6(20.3)	43.5(20.1)	61.77**	0.25	63.4(20.4)	47.1(20.1)	29.03**	0.14
GCPS disability (0-100)	57.0(27.7)	36.6(29.6)	23.99**	0.11	52.9(28.3)	40.5(29.6)	7.84**	0.04
SPPB function (0-12)	9.1(1.8)	9.7(1.5)	6.26*	0.03	9.2(1.8)	9.6(1.5)	1.85	0.01
SPPB pain (0-100)	29.6(29.2)	14.0(17.9)	19.08**	0.09	29.0(29.5)	16.2(18.0)	10.93**	0.06

Note. *$P < 0.05$, **$P < 0.01$. Adjusted models controlled for age, income, education, marital status, employment, body mass index, and study site. Abbreviation: NHB, non-Hispanic black; NHW, non-Hispanic white; GCPS, Graded Chronic Pain Scale; SPPB, Short Physical Performance Battery.

measures and pain and physical function outcomes. Interaction effects between race/ethnicity and each resilience factor are displayed in Table 5. There was a significant interaction (b = 1.94, 95% confidence interval [CI] = 0.26 to 3.62, $\Delta R^2 = 0.03$, $f^2 = 0.04$) between race/ethnicity and optimism with movement-evoked pain (overall model: $R^2 = 0.23$, $F(10, 164) = 4.71$, $P < 0.001$). The interaction plot (Figure 1A) revealed a negative association between optimism and movement-evoked pain in NHBs ($b = -1.67$, $P = 0.02$), which was not significant in NHWs (b = 0.27, $P = 0.57$). Similarly, a significant interaction (b = 1.44, 95% CI = 0.15 to 2.72, $\Delta R^2 = 0.03$, $f^2 = 0.04$) was found between race/ethnicity and positive well-being (overall model $R^2 = 0.23$, $F(10, 164) = 4.34$, $P < 0.001$). Simple slopes analysis (Figure 1B) revealed that for NHBs there was a trend toward an inverse relationship between positive well-being and movement-evoked pain ($b = -0.95$, $P = 0.10$); however, these effects were in the opposite direction for NHWs ($b = 0.48$, $P = 0.13$). The interaction (b = 1.02, 95% CI = 0.04 to 1.99, $\Delta R^2 = 0.02$, $f^2 = 0.03$) between race/ethnicity and PA for movement-evoked pain was also significant (Figure 1C), with the overall model explaining 22% of the variance in SPPB pain scores (overall model: $R^2 = 0.22$, $F(10, 163) = 4.74$, $P < 0.001$). Movement-evoked pain was lower in NHWs as PA decreased ($b = 0.59$, $P = 0.03$); however, this relationship was nonsignificant for NHBs ($b = -0.49$, $P = 0.30$). Supplementary Table 1 reports the full linear regression analysis for significant movement-evoked pain results. There were no other significant moderation effects observed in the analysis, including those for pain intensity, pain disability, and physical function ($P > 0.05$).

DISCUSSION

Race/ethnic differences in clinical and experimental pain have been widely documented (8, 9, 13), and a growing literature has recognized resilience as an important resource for individuals with chronic pain (4, 37). Expanding on prior research, our study provides evidence regarding the influence of psychosocial resilience on pain and functioning among adults with knee OA and is the first to examine whether these relationships are differentially expressed across race/ethnicity.

Table 5. Moderation analysis for interactions between psychosocial resilience measures and race/ethnicity

	GCPS Pain			GCPS Disability			SPPB Function			SPPB Pain		
	b	SE	*P*	*b*	SE	*P*	*b*	SE	*P*	*b*	SE	*P*
Interactions												
Trait Resilience X Race/ Ethnicity	2.57	3.94	.516	2.25	5.45	.679	-.40	.30	.187	8.52	6.11	.165
Optimism X Race/ Ethnicity	.50	.63	.422	-.25	1.00	.805	-.01	.06	.859	1.94	.85	.024
Positive Well-Being X Race/Ethnicity	.67	.45	.142	.13	.62	.827	.02	.04	.622	1.44	.65	.028
Social Support X Race/ Ethnicity	.11	.17	.502	-.01	.25	.956	.00	.01	.964	.32	.22	.150
Positive Affect X Race/ Ethnicity	.29	.46	.533	.23	.61	.702	.01	.04	.717	1.02	.49	.041

Note. Models adjusted for age, income, education, marital status, employment, BMI, and study site.
Abbreviation: *b*, unstandardized beta; GCPS, Graded Chronic Pain Scale; SPPB, Short Physical Performance Battery.

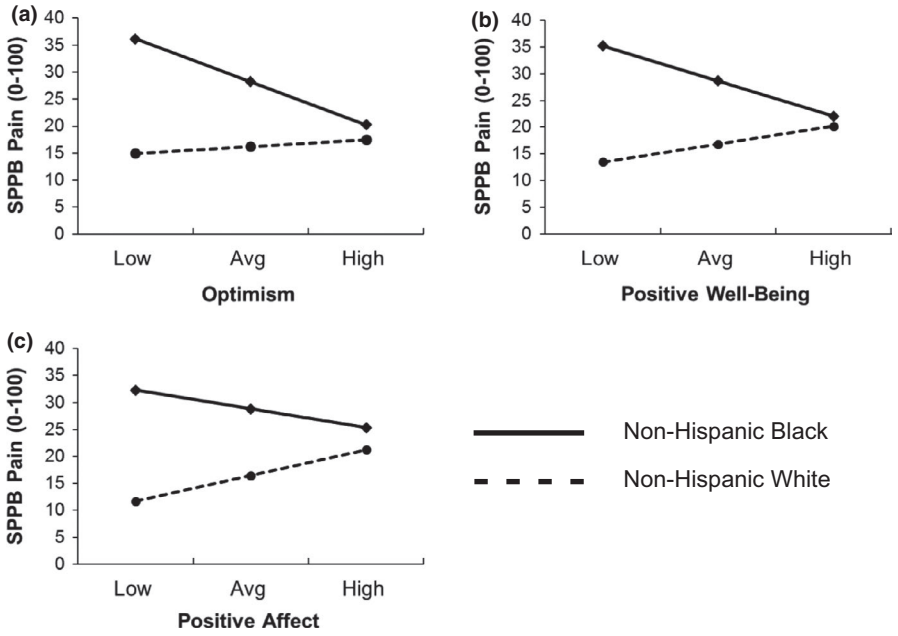

Figure 1. Illustration of the associations between measures of psychosocial resilience and race/ethnicity for movement-evoked pain. As depicted in panels (a) and (b), lower levels of optimism and positive well-being were associated with higher movement-evoked pain for non-Hispanic blacks. For non-Hispanic whites (c), lower PA was associated with attenuated movement-evoked pain.

Aligning with study hypotheses, we found that more psychologically resilient individuals report lower clinical pain and disability and experience higher levels of functional performance, signifying that resilience may promote more adaptive functioning by attenuating adverse pain outcomes. Although risk mechanisms (eg, catastrophizing, depression) associated with chronic pain vulnerability have traditionally dominated the literature, studies focusing on resilience suggest that positive psychological factors are instrumental in supporting a number of health benefits, including higher quality of life, lower clinical pain and disability, adaptive pain coping, greater physical functioning, reduced NA, and positive pain adjustment (4, 16, 37). These effects extend beyond those associated with pain-related vulnerability, as recent evidence supports the unique contribution of resilience factors in psychological health (38). Together, these findings suggest that capitalizing on positive resources may increase one's capacity for effectively managing their pain.

Corroborating the health care disparities literature, as well as our own work (13, 39), NHBs with knee OA reported greater knee pain severity and disability, poorer functional performance, and greater knee pain with movement than did NHWs. However, there were no distinct group differences in measures of psychosocial resilience despite a vast literature reporting race/ethnic differences in pain coping (21, 22). In fact, overall pain-coping strategies are used more frequently among NHBs, particularly passive coping methods, such as catastrophizing, hoping, and praying (8, 21, 22). Furthermore, perceived racial discrimination (39), catastrophizing (40), and prayer (22, 40) have all been found to partially account for observed racial/ethnic differences in both experimental and clinical pain. Although there is some evidence that positive psychological factors may also differ across race/ethnicity, results have been mixed, and studies have predominantly been conducted in nonclinical (ie, pain-free) populations. Of these, similar levels of optimism (20), resilience (41), social support (41), and dispositional hope (42) have been observed across race/ethnicity, whereas other studies have found higher PA among NHBs relative to white participants (42, 43). In the two studies exploring pain-coping differences in an OA population, one found lower arthritis self-efficacy in NHBs (12); however, comparable levels of pain self-efficacy across race/ethnicity have also been noted (22). Although the present study provides a unique opportunity to expand upon this limited research, future work is warranted to delineate potential race/ethnic differences in other positive resources known to foster resilience in OA.

Despite similar levels of psychosocial resilience across race/ethnicity, optimism and positive well-being had an inverse association with movement-evoked pain in NHBs, suggesting that these resources may be particularly protective in this group. Efforts to enhance optimistic beliefs and positive well-being, as opposed to simply reducing risk, may be a critical directive for yielding improvements in pain among NHBs. Even more striking, we found that lower levels of PA were protective against movement-evoked pain among NHWs, with a similar pattern noted for positive well-being (although nonsignificant). Although this may seem counterintuitive, especially given the wealth of literature denoting the measurable health benefits of PA, it is also known that the level of activation or arousal can dictate the directionality of these effects (44). Indeed, studies suggest an adverse effect of high-arousal positive

emotions on health, that are ostensibly due to increased sympathetic activation (44). Consistent with this interpretation, recent empirical work has noted the association between low-arousal PA and lower C-reactive protein in patients with breast cancer (45). Similarly, Hassett and colleagues showed that individuals with low positive and NA (low affect balance style, reflective of a calm or relaxed temperament) had an attenuated risk of experiencing a pain or somatization disorder (46). Together, these findings point to the possibility that low-arousal PA may dampen physiological arousal, which could lead to the downregulation of neural processes associated with pain facilitation in NHWs. This hypothesis is speculative but certainly encourages further exploration.

Notably, the associations of psychological resilience with self-reported measures of pain and function were largely independent of racial/ethnic group, yet a distinct pattern emerged for movement-evoked pain. Research designed to explore the effects of movement-related pain have found it to be associated with poorer physical performance and work-related disability, and there is evidence for its unique contribution to self-reported and functional measures of disability, beyond the variance attributed by spontaneous pain measures (34, 35). Thus, movement-evoked pain may reflect a more disability-relevant index of the pain experience. In light of our own findings, increased pain during movement may initiate a pattern of avoidance that reduces activity engagement and thereby exacerbates pain and functional limitations. Intervening across measures of resiliency may help mitigate these effects. Importantly, efforts to understand how these relationships operate across racial/ethnic groups may facilitate initiatives that target the improvement of movement-evoked pain.

There is a growing appreciation for the contribution of positive psychosocial factors in pain adaptation and interest in whether these crucial resources have utility in clinical practice. Although cognitive-behavioral therapy remains the gold standard of psychological treatments, not all patients benefit equally, and thus therapeutic effects tend to be modest (47). Research focused on cultivating resilience through the strengthening of psychological assets (eg, PA, gratitude, optimism) has shown promise in improving both pain and psychological outcomes (48–50), yet little is known about how these interventions operate in OA populations. An additional shortcoming of previous research has been the failure to consider how psychosocial resilience manifests differently across racial/ethnic groups and whether this may be a contributor to pain disparities. Given race-specific sociocultural influences (eg, disproportionate exposure to racial discrimination and socioeconomic inequities among NHBs) on pain, emotional well-being, and physical health (39), the factors that promote positive adjustment may not be equivalent across NHBs and NHWs. Understanding how racial/ethnic groups experience pain and the protective mechanisms that influence those variations may be a critical step in optimizing our current pain treatments.

Several limitations merit acknowledgement. First, because of the cross-sectional nature of the study, conclusions are limited as to the direction of the observed relationships. Second, our study population consisted of NHBs and NHWs with knee OA, most of whom were older in age; therefore, it is unclear whether results are generalizable to other demographic (eg, other chronic pain conditions, younger cohorts) and racial/ethnic groups. Third, although we adjusted analyses for many covariates known to potentially affect the outcomes of interest, it is possible that other unmeasured social or demographic factors confounded these relationships. This limitation warrants particular caution in interpreting racial/ethnic disparities. Fourth, although we had a large sample size of 201 individuals with OA, it is likely that our study was not adequately powered to detect interaction effects amongst other key variables found to be nonsignificant. We also recognize that the effect sizes for our significant interactions were small and only contributed an additional 2%-3% of the variance in outcomes. Future studies with larger samples are needed to replicate findings and to ascertain their clinical relevance. And finally, a large number of statistical tests were conducted, which could increase Type I error. However, given that there was a clear pattern to our results, in that measures of resilience had a stronger impact on movement-evoked pain in the moderation analysis (relative to functional performance and self-reported measures of pain and disability), we do not believe this reflects spurious findings.

Although these factors may limit the generalizability of our findings, this study represents an important step in understanding how psychosocial resilience differentially influences pain and functioning across racial/ethnic groups. Some strengths include the recruitment of a large community sample and the inclusion of several measures of resilience rather than relying on a unitary measure. Additionally, the current investigation is the first to examine the contributions of resilience to movement-evoked pain. Measures of dynamic pain during movement have been suggested to be a stronger predictor of disability (35) than spontaneous pain measures; however, most studies to date have not routinely assessed task-oriented pain. Because activity-related pain is a driver of disability, utilizing real-time functional pain measurements may be a more sensitive method by which to assess pain burden.

In summary, our findings support the larger literature on race/ethnic differences in pain and physical functioning and suggest that positive psychosocial measures may have salutary effects on knee OA symptoms. Given the limited research in this area, continued work is warranted as resilience factors are amendable and may be important targets for medical care designed to prevent and treat knee OA pain. In particular, treatments that address optimism and positive well-being in NHBs may have downstream effects that reduce the overall burden of pain in this group. Examining the factors that affect pain and physical functioning may ultimately allow for the development of more optimal and culturally sensitive treatments to alleviate chronic pain.

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