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Perceived racial discrimination, but not mistrust of medical researchers, predicts the heat pain tolerance of African Americans with symptomatic knee osteoarthritis

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Abstract

Objective—Studies have shown that perceived racial discrimination is a significant predictor of clinical pain severity among African Americans. It remains unknown whether perceived racial discrimination also alters the nociceptive processing of painful stimuli, which, in turn, could influence clinical pain severity. This study examined associations between perceived racial discrimination and responses to noxious thermal stimuli among African Americans and non-Hispanic whites. Mistrust of medical researchers was also assessed given its potential to affect responses to the noxious stimuli.

Method—One hundred and thirty (52% African American, 48% non-Hispanic white) community-dwelling older adults with symptomatic knee osteoarthritis completed two study sessions. In session one, individuals provided demographic, socioeconomic, physical and mental health information. They completed questionnaires related to perceived lifetime frequency of racial discrimination and mistrust of medical researchers. In session two, individuals underwent a series of controlled thermal stimulation procedures to assess heat pain sensitivity, particularly heat pain tolerance.

Results—African Americans were more sensitive to heat pain and reported greater perceived racial discrimination as well as greater mistrust of medical researchers compared to non-Hispanic whites. Greater perceived racial discrimination significantly predicted lower heat pain tolerance for African Americans but not non-Hispanic whites. Mistrust of medical researchers did not significantly predict heat pain tolerance for either racial group

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Conclusion—These results lend support to the idea that perceived racial discrimination may influence the clinical pain severity of African Americans via the nociceptive processing of painful stimuli.

Introduction

Previous research has noted significant differences between African Americans and non-Hispanic whites in the presence of osteoarthritis (OA) and its symptoms, particularly pain (Allen, Helmick, Schwartz, DeVellis, Renner, & Jordan, 2009; Allen, Oddone, Coffman, Keefe, Lindquist, & Bosworth, 2010; Jordan et al., 2007). These differences include findings of greater OA prevalence and associated pain severity for African Americans compared to non-Hispanic whites (see Allen, 2010 for review). For African Americans, this often results in higher levels of pain-related physical and psychosocial disability than their non-Hispanic white counterparts (Cano, Mayo, & Ventimiglia, 2006). Disparities in the experience of OA-related pain seem to persist independent of inequalities in health care, and a growing body of research has begun to apply a biopsychosocial rubric toward identifying and describing important factors that shape the experience of OA within particular racial groups (Somers, Keefe, Godiwala, & Hoyler, 2009). The biopsychosocial model posits that pain is shaped by interactions among biological, psychological, and social variables, all of which are involved in an individual's identification with one or more racial groups (Gatchel, Peng, Peters, Fuchs, & Turk, 2007).

One seemingly important biopsychosocial factor that only recently has been explored in relation to racial disparities in pain is perceived racial discrimination, which African Americans more frequently report than non-Hispanic whites (Williams, Neighbors, & Jackson, 2003). Perceptions of racial discrimination have been shown to exert a deleterious impact on physical and mental health (Pascoe & Smart-Richman, 2009), particularly among racial minority groups. However, only two previous studies have examined the relationship between perceived racial discrimination and pain in samples consisting of African Americans and non-Hispanic whites. In one study, major lifetime discrimination was the strongest predictor of back pain among African Americans, but not non-Hispanic whites, when compared to other physical and mental health variables (Edwards, 2008). In a second study composed entirely of African American men, perceptions of racial discrimination were associated with greater reported bodily pain, even after controlling for socioeconomic and health-related characteristics (Burgess et al., 2009). Taken together, these studies implicate perceived racial discrimination as a risk factor for the experience of greater clinical pain in African Americans. To date, no studies have examined whether perceived racial discrimination is also related to the pain experiences of individuals with OA.

The mechanisms whereby perceived racial discrimination may influence pain among African Americans were not addressed in previous studies (Burgess et al., 2009; Edwards, 2008); however, discrimination could influence pain severity by altering nociceptive processing of painful stimuli. Indeed, previous laboratory pain studies have shown African Americans to be more pain sensitive to multiple modalities of experimental noxious stimulation (e.g., heat, cold, ischemic pain) (Campbell, Edwards, & Fillingim, 2005; Rahim-Williams, Riley, Williams, & Fillingim, 2012), and produce less robust endogenous pain inhibition compared to their non-Hispanic white counterparts (Campbell, France, Robinson, Logan, Geffken, & Fillingim, 2008). However, it remains to be determined whether perceived racial discrimination is associated with enhanced sensitivity to experimental pain among African Americans.

When examining the role of perceived racial discrimination in explaining racial disparities in responses to controlled noxious stimuli in the laboratory, individuals' mistrust of medical

researchers should be considered. Mistrust of medical researchers has been implicated as a factor underlying the underrepresentation of African Americans and other racial minorities in medical research (Shavers, Lynch, & Burmeister, 2002). Indeed, African American patients describe mistrust of the medical community as a prominent barrier to participation in clinical research (Corbie-Smith, Thomas, Williams, & Moody-Ayers, 1999). Although mistrust of medical researchers has been examined as a barrier preventing the inclusion of African Americans and other minorities into research studies, much less is known about the influence of medical mistrust on key criterion variables among African Americans who are actively recruited into a study. For instance, in laboratory studies of pain tolerance, participants are often asked to indicate when they can no longer stand the pain. Previous research suggests that African Americans exhibit similar heat pain thresholds but lower heat pain tolerance levels than non-Hispanic whites (Rahim-Williams, Riley, Williams, & Fillingim, 2012), and these differences in heat pain tolerance may be influenced by African Americans' mistrust of medical researchers. One could speculate that African Americans, particularly those who report greater perceived racial discrimination, are more likely to mistrust the researchers' declaration that the heat will not produce a burn or injury. As a result, African Americans may demonstrate lower heat pain tolerances than non-Hispanic whites, in part, because they are more mistrusting of medical researchers and tend to terminate the procedure relatively quickly. Again, the role of mistrust of medical researchers in explaining racial disparities in laboratory-based pain studies is speculative and remains to be tested.

The goal of the current study was to examine perceived racial discrimination and mistrust of medical researchers as potential factors underlying racial disparities in experimental pain sensitivity in a sample of older, community-dwelling adults with symptomatic knee OA. Using controlled noxious thermal stimuli in a laboratory setting, we tested the following hypotheses: 1) African Americans will demonstrate lower heat pain tolerance than non-Hispanic whites, 2) African Americans will report greater perceived racial discrimination and mistrust of medical researchers compared to non-Hispanic whites, 3) perceived racial discrimination will be correlated with mistrust of medical researchers and both factors will be significant predictors of heat pain tolerance, particularly among African Americans, and 4) perceived racial discrimination and mistrust of medical researchers will mediate the relationship between race and heat pain tolerance.

Materials and Methods

Participants

The current study is part of a larger ongoing project that aims to enhance the understanding of racial/ethnic differences in pain and limitations among individuals with osteoarthritic disease (Understanding Pain and Limitations in Osteoarthritic Disease, UPLOAD). The UPLOAD study is a multi-site investigation that recruits participants at the University of Florida and the University of Alabama-Birmingham. The participants described in the current study were recruited at both study sites between January, 2010 and February, 2012. The measures and procedures described below are limited to those involved in the current study.

Participants were 130 older community-dwelling adults (67 African Americans, 63 non-Hispanic whites) with symptomatic knee osteoarthritis who were recruited via posted fliers, radio and print media advertisements, orthopedic clinic recruitment, and word-of-mouth referral. This study was reviewed and approved by the University of Florida and University of Alabama-Birmingham Institutional Review Boards. Participants provided informed consent and were compensated for their participation.

Screening Session

Individuals completed a study screening session via telephone in order to determine whether they met criteria for study inclusion. The following demographic, socioeconomic and health data were also obtained as part of the screening session: self-reported sex, age educational attainment, annual household income, and number of household occupants, as well as a health history pertaining to painful experiences related to osteoarthritis. Only those individuals who identified their racial background as African American or non-Hispanic white were included in the current study.

Criteria for inclusion into the study were as follows: 1) between 45 and 85 years of age; 2) unilateral or bilateral symptomatic knee osteoarthritis based upon American College of Rheumatology criteria (Altman et al., 1986), regardless of radiographic evidence of osteoarthritis; and, 3) availability to complete the multiple session protocol. Individuals were excluded from participation if they met any of the following criteria: 1) prosthetic knee replacement or other clinically significant surgery to the affected knee; 2) uncontrolled hypertension, heart failure, or history of acute myocardial infarction; 3) peripheral neuropathy; 4) systemic rheumatic disorders including rheumatoid arthritis, systemic lupus erythematosus, and fibromyalgia; 5) daily opioid use; 6) cognitive impairment (Mini Mental Status Exam (MMSE) score ≤ 22); 7) excessive anxiety regarding protocol procedures (e.g., controlled noxious stimulation procedures); and, 8) hospitalization within the preceding year for psychiatric illness.

Questionnaire Session

Following the screening session, individuals completed study questionnaires electronically either at home or at the laboratory. Study questionnaires were completed prior to individuals' involvement in the health assessment session and controlled noxious stimulation session (described in greater detail below). The following questionnaires were completed:

Experiences of Discrimination (EOD) Scale. The EOD is a well validated and reliable measure of lifetime occurrences of discrimination and was used to assess individuals' perceptions of racial discrimination (Krieger, Smith, Naishadham, Hartman, & Barbeau, 2005). The EOD asks the question, "How often have you experienced discrimination, been prevented from doing something, or been hassled or made to feel inferior in any of the following situations because of your race, ethnicity, or color?" The question is followed by responses options that include the following nine situations: at school; getting hired or getting a job; at work; getting housing; getting medical care; getting service in a store or restaurant; getting credit, bank loans, or a mortgage; on the street or in a public setting; from the police or in the courts. Respondents chose from the following responses: "never," "once," "two or three times," "four or more times." In the current study, the frequency of experiences reported on the EOD was used as the primary measure of perceived racial discrimination, which is consistent with previous research that has examined perceived racial discrimination and clinical pain severity (Edwards, 2008).

Trust in Medical Researchers Scale (TMRS). The TMRS is a 12-item measure with demonstrated validity and internal consistency (Mainous, Smith, Geesey, & Tilley, 2006). The items are measured on a scale of agreement from 1 (strongly disagree) to 5 (strongly agree) with some items reverse coded so that higher scores indicate greater trust in medical researchers, while lower scores indicate greater mistrust of medical researchers. In the current study we used the summary score of the TMRS as an overall indicator of individuals' mistrust of medical researchers.

Western Ontario and McMaster Universities Index of Osteoarthritis (WOMAC). The WOMAC was used to assess individuals' reports of osteoarthritic symptoms (Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988). The WOMAC is frequently used in research to assess individuals' retrospective self-report of knee and hip osteoarthritis symptoms. The subscales of the WOMAC measure pain, stiffness, and physical function. The pain subscale of the WOMAC (WOMAC-pain; range 0–20) was used for the current study's purposes as a general indicator of osteoarthritic pain severity during the 48 hours preceding evaluation. High construct validity and test-retest reliability has previously been reported for the WOMAC (Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988).

Center for Epidemiological Studies Depression Scale (CES-D). The CES-D is a 20-item self-report tool that measures symptoms of depression including depressed mood, guilt/worthlessness, helplessness/hopelessness, psychomotor retardation, loss of appetite and sleep disturbance (Radloff, 1977). The CES-D has previously been used in research involving psychiatric and non-psychiatric samples, as well as clinical samples with medical illness. The validity and internal consistency of the CES-D in the general population has been reported to be acceptable (Radloff, 1977).

Health assessment session—All individuals underwent a bilateral knee joint evaluation by an experienced examiner (i.e., the study rheumatologist or study nurse practioner). Using the American College of Rheumatology criteria for symptomatic knee osteoarthritis, the individuals' most symptomatic/painful knee was identified and classified as the index knee for assessment during the controlled noxious stimulation session.

Controlled noxious stimulation session—Within four weeks of the health assessment session, individuals completed the controlled noxious stimulation session. For the 48 hours preceding their controlled noxious stimulation session, individuals were instructed to refrain from using PRN (as needed) opioid analgesic medications. All individuals underwent a series of controlled thermal stimulation procedures to assess heat pain tolerance. Heat pain tolerance refers to the maximum stimulus intensity (i.e., temperature, °C) a person is willing to tolerate before discontinuing due to pain. Heat pain tolerance was recorded as the temperature at which the individual discontinued the heat stimulus. Heat pain tolerance was assessed on individuals' index knee and ipsilateral ventral forearm using a Medoc Pathway Neurosensory Analyzer (Medoc, Ltd., Ramat Yishai, Israel) with a small 16 × 16 mm thermode in accordance with an ascending method of limits. From a baseline of 32°C, probe temperature increased at a rate of 0.5°C/sec until participants responded by pressing a button to indicate when they were no longer able to tolerate the pain. Three trials of heat pain tolerance were completed separately on the index knee and forearm for each individual (6 total trials of heat pain tolerance per individual). The position of the thermode was altered slightly between trials (though it remained on the index knee and ventral forearm). For each measure at each anatomical site, the average of all three trials was computed for use in subsequent analyses.

Selected control variables

As noted above, the question of interest related to whether racial differences in perceived racial discrimination and mistrust of medical researchers predicted racial differences in heat pain sensitivity, particularly and pain tolerance. A variety of variables that might be related to perceptions of racial discrimination and heat pain tolerance were identified and used as covariates with the analytic models described below. These included demographic variables such as age, sex (coded as 0 = women, 1 = men), study site location (coded as 0 = Florida, 1 = Alabama-Birmingham), educational attainment (coded as 0 = completed high school or less, 1 = at least some college), and household income (coded as 0 = below the poverty line,

1 = above the poverty line). Determination of whether a participant fell above or below the poverty line was based upon reported annual household income and the number of occupants residing within the household using the 2012 HHS poverty guidelines (U. S. Department of Health and Human Services, 2012). Moreover, depressive symptoms and OA pain severity within the past 48 hours were also considered to be potential control variables and examined accordingly.

Data reduction and analysis

All data were analyzed using SPSS, version 20 (IBM; Chicago, IL). All participants provided complete demographic data (e.g., sex, age); however, a small portion of missing data existed for one or more key study variables such as perceived racial discrimination and mistrust of medical researchers (< 5% of the total data comprising each measure). Data appeared to be missing at random. Rather than exclude the individuals for whom data was missing from analysis, a simple data imputation method was completed using the macro for Hot Deck imputation (Myers, 2011). This data imputation method is well validated and accepted in the statistical community, and resulted in complete study data for each of the 130 study participants. Descriptive data for the sample are presented overall and separately for African Americans and non-Hispanic whites; data are presented as percentages or as means and standard deviations. Racial differences on categorical variables were assessed using Chi-square tests, while racial differences on continuous variables were assessed using analysis of covariance (ANCOVA). Zero order relationships among all study variables were assessed separately for African Americans and non-Hispanic whites using Pearson correlations. To assess the specific relationships of perceived racial discrimination and mistrust of medical researchers with heat pain tolerance within each racial group, a series of hierarchical linear regressions was completed separately for African Americans and non-Hispanic whites controlling for selected covariates. The bootstrapping technique and macro created and described by Preacher and Hayes (2008) for obtaining a 95% percentile confidence interval was utilized to test whether perceived racial discrimination and/or mistrust of medical researchers significantly mediated the association between race and heat pain tolerance. Bootstrapping is a non-parametric resampling procedure that has been shown to be a viable alternative to other normal-theory tests of the intervening mediator between the independent and dependent variables (Williams & MacKinnon, 2008). The percentile confidence interval was incorporated to help minimize potential of Type I error related to the test mediation (Fritz, Taylor, & MacKinnon, 2012). Partial eta squared (η_p^2) and Cohen's f^2 effect sizes are presented where appropriate following the conventions of Cohen (1988) for tests of adjusted mean differences (ANCOVA) and linear relationships (hiearchical regressions), respectively. Per Cohen's guidelines, $\eta_p^2 = 0.01$ is considered a small effect, $\eta_p^2 = 0.06$ a medium-sized effect and $\eta_p^2 = 0.14$ a large effect. Similarly, $f^2 = 0.02$ is considered a small effect, $f^2 = 0.15$ a medium-sized effect and $f^2 = 0.35$ a large effect.

Results

Participant characteristics and examination of control variables

Table 1 displays demographic, socioeconomic, and descriptive characteristics separately for African Americans and non-Hispanic whites. Although more women than men participated in this study, men and women were equally distributed across the two racial groups ($\chi^2 = 0.42$, $p = .52$). Indeed, women experience knee osteoarthritis symptoms at twice the rate of men (Hunter, McDougall & Keefe, 2008). The majority of individuals who participated in this study were recruited from the University of Florida site; however, the distribution of African Americans and non-Hispanic whites recruited across the two study sites trended toward a statistically significant difference ($\chi^2 = 3.58$, $p = .06$). Regarding indicators of socioeconomic status, a greater proportion of African Americans reported having a high

school education or less ($\chi^2 = 8.19$, $p = .004$) and an annual household income that falls below the poverty line ($\chi^2 = 23.00$, $p < .001$) compared to non-Hispanic whites. On average African Americans were younger than their non-Hispanic white counterparts ($F_{1,128} = 8.66$, $p = .004$, $\eta_p^2 = .06$), and they reported greater depressive symptoms ($F_{1,128} = 4.24$, $p = .04$, $\eta_p^2 = .03$) and greater osteoarthritic knee pain over the last 48 hours ($F_{1,128} = 13.23$, $p < .001$, $\eta_p^2 = .09$).

Zero-order correlations among all study variables

Heat pain tolerance assessed at the knee was significantly correlated with heat pain tolerance assessed at the forearm for African Americans ($r = .83$, $p < .001$) and non-Hispanic whites ($r = .83$, $p < .001$). Accordingly, heat pain tolerance was averaged across the two body sites to create an overall index of heat pain tolerance. This overall index of heat pain tolerance is presented in the Pearson correlation matrix for all study variables (Table 2). Perceived racial discrimination was significantly and inversely correlated with heat pain tolerance for African Americans ($r = -.26$, $p = .03$) but not non-Hispanic whites ($r = -.06$, $p = .62$). Greater perceived racial discrimination was significantly correlated with greater mistrust of medical researchers for African Americans ($r = -.30$, $p = .04$) but not non-Hispanic whites ($r = -.03$, $p = .82$), Mistrust of medical researchers was not significantly correlated with heat pain tolerance for African Americans ($r = .12$, $p = .35$) or non-Hispanic whites ($r = -.04$, $p = .75$). There were significant correlations among the selected control variables and heat pain tolerance for African Americans and non-Hispanic whites, thereby justifying their inclusion in the study model as statistical covariates. In particular, the following variables were selected for statistical control and are referred to as “covariates” from this point forward: sex, age, study site location, educational attainment, household income, depressive symptoms, and OA pain severity within the past 48 hours.

Racial difference in heat pain tolerance

Results of an ANCOVA adjusted for covariates revealed that African Americans demonstrated significantly lower heat pain tolerance ($F_{1,121} = 20.65$, $p < .001$, $\eta_p^2 = .15$) relative to their non-Hispanic white counterparts, which is indicative of greater sensitivity to heat pain for African Americans.

Racial differences in perceived discrimination and mistrust of medical researchers

After adjustment for covariates, two additional ANCOVAs were completed to examine racial differences in perceived discrimination and mistrust of medical researchers. It was revealed that mean perceived racial discrimination was reported to be significantly greater for African Americans compared to non-Hispanic whites ($F_{1,121} = 19.25$, $p < .001$, $\eta_p^2 = .14$). The non-Hispanic whites reported significantly greater trust in medical researchers compared to the African Americans ($F_{1,121} = 12.59$, $p = .001$, $\eta_p^2 = .09$), who were more mistrusting of medical researchers.

Multivariable models predicting heat pain tolerance

In examining the associations between perceived racial discrimination and heat pain tolerance, we evaluated two hierarchical linear regression models, one including all African American participants, and another including all non-Hispanic white participants. Sex, age, study site location, educational attainment, and household income were entered first as predictors (Step 1), followed by depressive symptoms and OA pain severity within the past 48 hours (Step 2), and finally reports of perceived racial discrimination (Step 3). The results of these hierarchical models are presented in sequential fashion, such that Step 1 presents the regression coefficients only for that step, while step 2 presents adjusted coefficients controlling for the predictors entered in Step 1, and Step 3 presents the adjusted coefficient

controlling for the predictors entered in Step 1 and Step 2. Among African Americans, the single strongest predictor of heat pain tolerance was perceived racial discrimination (β = −.30, p = .02, f^2 = .12), which uniquely explained 8% of the variance. Greater perceived racial discrimination was associated with lower heat pain tolerance. The next strongest predictors of heat pain tolerance for African Americans were individuals' sex and age (see Table 3). These findings contrast with those of the non-Hispanic whites, for whom only sex was a significant predictor of heat pain tolerance (Table 3). Among non-Hispanic whites, the association between perceived racial discrimination and heat pain tolerance was minimal (β = −.04, p = .73, f^2 = .01), accounting for only 1% of the variance in heat pain tolerance. .

Two additional hierarchical linear regressions were carried out separately for African Americans and non-Hispanic whites to examine the associations between mistrust of medical researchers and heat pain tolerance. Covariates were entered into Steps 1 and 2 of this model in the same manner described above; however, the final variable entered for this analysis was mistrust in medical researchers (Step 3). Table 4 shows that mistrust of medical researchers was not a significant predictor of heat pain tolerance for African Americans (β = .09, p = .67, f^2 = .01) or non-Hispanic whites (β = −.03, p = .82, f^2 = .01).

Mediation

To determine if perceived racial discrimination and/or mistrust of medical researchers significantly mediated the association between race (coded: 0 = African American, 1 = non-Hispanic white) and heat pain tolerance, two separate bootstrap analyses were conducted to estimate the direct and indirect effects. A 95% percentile confidence interval was calculated to determine the significance of the indirect (i.e., mediation) effect. The bootstrapped mediation analysis indicates whether the direct *effect* (path *c*') of the independent variable (race) on the dependent variable (heat pain tolerance) as well as the *indirect effect* (path *a x b*) of the independent variable on the dependent variable through a proposed mediator (perceived racial discrimination or mistrust of medical researchers) is significant. Path *a* denotes the effect of the independent variable on the mediator, whereas, path *b* is the effect of the mediator on the dependent variable.

Bootstrapping procedure

The mediation model, adjusted for covariates, examining the relationship between race and heat pain tolerance through perceived racial discrimination accounted for a significant portion of variance in heat pain tolerance (R^2 = .35, p < .001). The direct effect (path *c*') of race on heat pain tolerance was significant (β = .32, p < .001). The indirect effect (path *a x b*) of race on heat pain tolerance through perceived racial discrimination had a point estimate of .56 and a 95% percentile confidence interval of .15 to 1.09. This confidence interval suggests that, even after adjusting for covariates, the indirect effect of *a x b* is significantly different from zero (i.e., the null effect) at p < .05. The directions of paths *a* (β = −.42, p < .001) and *b* (β = −.30, p < .01) are consistent with the interpretation that being African American is associated with greater perceptions of racial discrimination, which in turn, is associated with lower heat pain tolerance. Thus, perceived racial discrimination is a significant mediator of the association between race and heat pain tolerance.

The adjusted mediation model examining the relationship between race and heat pain tolerance through mistrust of medical researchers also accounted for a significant portion of variance in heat pain tolerance (R^2 = .30, p < .001). However, indirect effect (path *a x b*) of race on heat pain tolerance through mistrust of medical researchers had a point estimate of .09 and a 95% percentile confidence interval of −.27 to .52, which suggests the indirect effect is not significantly different from zero. Thus, mistrust of medical researchers is not a significant mediator of the association between race and heat pain tolerance.

Discussion

In this study of older, community-dwelling individuals with symptomatic knee OA, African Americans reported greater pain severity and significantly lower heat pain tolerance when compared to non-Hispanic whites. The large difference between African Americans and non-Hispanic whites for OA pain severity within the past 48 hours is consistent with previous clinical literature regarding painful OA of the knee (Jordan et al., 2007). Further, the effect size for the significant racial difference in heat pain tolerance in the current study was large in size, which aligns nicely with the findings from a recently published quantitative review that comprehensively addressed differences between African Americans and non-Hispanic whites across multiple experimental pain responses (Rahim-Williams, Riley, & Fillingim, 2012).

Of particular relevance to the current study, African Americans reported greater lifetime frequency of discrimination and more mistrust of medical researchers compared to non-Hispanic whites. These findings corroborate previous studies showing large racial disparities in perceived discrimination and mistrust of the medical community (Corbie-Smith, Thomas, Williams, & Moody-Ayers, 1999; Williams, Neighbors, & Jackson, 2003). Consistent with our hypothesis, greater perceived racial discrimination was significantly correlated with mistrust of medical researchers for African Americans but not non-Hispanic whites. These associations might suggest that the racial minorities who perceive the greatest amount of discrimination in their lives may be the least likely to present for participation in biomedical research due to mistrust of researchers, which may make it difficult for investigators to elucidate associations between discrimination and pain-related outcomes. In the future, researchers are encouraged to devise creative, grassroots means of community outreach and recruitment in an effort to ensure that their laboratory-based studies of racial differences in experimental pain are not overly biased by individuals' willingness to participate in research and the trust that is inherent in this willingness.

The greatest difficulties seem to lie not in the measurement of racial differences in pain but in the explanation of these differences. Over the years it has become apparent that racial discrimination exerts a deleterious effect on the overall physical and mental health of racial minorities, particularly African Americans (Pascoe & Smart-Richman, 2009). More recently, it has been shown that perceived racial discrimination may be an important factor contributing to racial differences in clinical pain severity (Burgess et al., 2009; Edwards, 2008). The current study expands upon this line of investigation by being the first to associate perceived racial discrimination with racial differences in response to an experimental heat pain stimulus in a sample of adults with symptomatic knee OA. Greater perceived racial discrimination was significantly related to lower heat pain tolerance for African Americans but not non-Hispanic whites. This finding does not imply that non-Hispanic whites are somehow buffered from the deleterious effects of discrimination, but rather this lack of relationship for non-Hispanic whites was likely due to the very low levels of perceived racial discrimination reported by this group. Being African American was associated with greater perceptions of racial discrimination and, in turn, greater perceptions of racial discrimination were associated with lower heat pain tolerance. Thus, perceived racial discrimination was a significant mediator of the association between race and heat pain tolerance. Our expectation that African Americans would demonstrate lower heat pain tolerance than non-Hispanic whites, in part, because they were more mistrusting of medical researchers was not supported. This finding suggests that the lower heat pain tolerance demonstrated by African Americans was not influenced by researcher mistrust or a response bias due to mistrust. Therefore, we are left to speculate about other potential mechanisms linking perceived racial discrimination with the nociceptive processing of painful stimuli.

There are multiple biopsychosocial pathways by which racial discrimination may affect pain responses. One interesting possibility is hypervigilance, an enhanced state of sensory sensitivity accompanied by an exaggerated intensity of behaviors whose purpose is to detect threats (Crombez, Van Damme, & Eccleston, 2005). Frequent experiences of racial discrimination may contribute to enhanced hypervigilance and perceptual amplification among African Americans, which could, in turn, result in reduced tolerance for painful stimulation. Indeed, studies have reported higher levels of hypervigilance among African Americans exposed to discrimination compared to non-Hispanic whites (Carter & Forsyth, 2010). Further, hypervigilance has been shown to partially explain racial differences in response to multiple experimental pain stimuli (Campbell, Edwards, Fillingim, 2005). Another consequence of racial discrimination that may contribute to the nociceptive processing of painful stimuli is physiological changes to the neuroendocrine, autonomic, and immune systems (Gatchel, Peng, Peters, Fuchs, & Turk, 2007). Numerous studies have shown that perceived discrimination is associated with chronic stress (Williams & Mohammed, 2009; Williams, Neighbors, & Jackson, 2003). Unlike acute stressors, which induce transient alterations of cortisol and pro-inflammatory cytokines generally considered adaptive for maintaining homeostasis (de Kloet, 2004; Tracey, 2002), chronic stressors (like frequent discrimination) invoke maladaptive physiological alterations (Segerstrom & Miller, 2004). The physiological alterations produced by chronic stress have been shown to sensitize people to painful stimuli (Lisowska, Maslinksi, Maldyk, Zabek, & Baranowska, 2008), and could account for lower pain tolerance among African Americans.

The present study possesses some limitations that urge caution when interpreting the findings. First, the relationship between mistrust of medical researchers and heat pain tolerance was found to be non-significant for African Americans and non-Hispanic whites in correlational and multivariable analyses. The conclusion that mistrust of medical researchers was not associated with heat pain tolerance is novel, and as such, should be considered tentative. Despite the significant racial difference in mistrust of medical researchers, logic suggests an inherent selection bias in the current study, since the most mistrusting individuals likely did not present for study inclusion, which may have limited the amount of variance in mistrust of medical researchers that could be used to predict heat pain responses. Second, the study sample was limited to African Americans and non-Hispanic whites with symptomatic knee OA. As a result, no determination can be made about whether the association of perceived racial discrimination with nociceptive processing of painful stimuli is specific to African Americans, or whether the association might generalize to the experiences of racial minorities more broadly. One study has reported that perceived discrimination was associated with the presence of chronic pain conditions such as arthritis and low back pain among Asian Americans (Gee, Spencer, Chen, & Takeuchi, 2007), suggesting that perceived racial discrimination may influence pain responses across multiple racial minority groups. Future research addressing this topic should include multiple racial groups for comparison. Third, the cross-sectional nature of this study limits the ability to determine the direction of the association between perceived racial discrimination and altered heat pain perception. There is the possibility that some third factor contributed to greater perceived discrimination and lower heat pain tolerance. However, it is important to note that the relationship between perceived racial discrimination and heat pain tolerance in the current study remained significant after controlling for potentially confounding factors such as age and sex, educational attainment and annual household income, along with depressive symptoms and individuals' reports of OA pain severity within the past 48 hours. Lastly, the clinical relevance of heat pain tolerance in this study was not strongly supported given the lack of significant correlations between heat pain tolerance and OA pain severity within the past 48 hours. However, previous reports have substantiated the clinical relevance of experimental pain testing (Edwards, Sarlani, Wesselman, & Fillingim, 2005). The reasons

for the lack of association between experimental and clinical pain measures in the current cohort are unclear.

Despite these limitations, the current study highlights the importance of perceived racial discrimination as a contributor to the pain experiences of African Americans. Future research is needed to replicate this study's findings among other populations of African Americans and other racial minorities. Also, continued investigation of the mechanisms underlying the association between racial discrimination and the pain experiences of individuals with OA seems warranted, and future researchers studying pain in racial minority groups may wish to consider perceptions of discrimination as a potential correlate of individuals' pain experiences and other pain-related factors. Further, examining the association of discrimination with self-report versus reflex-based or brain imaging responses of pain could distinguish whether discrimination exerts its effects by influencing pain reporting, central pain processing, or both. Ultimately, the hope is that this line of investigation will help policy makers and public health officials better determine how to mitigate racial discrimination and promote equality in healthcare and the management of pain.

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Table 1

Participant characteristics

	AfricanAmericans N = 67			non-Hispanic whites N = 63			
Variable	**Mean**	**SD**	**Percentage**	**Mean**	**SD**	**Percentage**	**Significance**
Sex (women)							.52
Men			25.4			20.6	
Women			74.6			79.4	
Study site location							.06
UF			80.6			92.1	
UAB			19.4			7.9	
Educational attainment							.004
High school or less			56.7			31.7	
At least some college			43.3			68.3	
Annual household income							<.001
Above poverty line			62.7			96.8	
Below poverty line			37.3			3.2	
Age	54.9	5.8		58.5	7.9		.004
CES-D	10.8	6.5		8.3	7.3		.04
EOD frequency	9.0	9.2		1.9	3.3		<.001
TMRS	31.3	9.1		38.9	7.2		.001
WOMAC-pain	8.7	4.8		6.0	3.7		<.001
HPTo (°C)	44.7	2.8		46.8	1.8		<.001

Note: UF = University of Florida, UAB = University of Alabama-Birmingham; CES-D = Center for Epidemiological Studies Depression Scale; EOD frequency = Experiences of Discrimination Scale, frequency of occurrences; TMRS = Trust in Medical Researchers Scale, WOMAC-pain = Western Ontario and McMaster Universities Index of Osteoarthritis, pain subscale, HPTo = heat pain tolerance, (°C) = degrees Celsius

Table 2

Zero-order correlations for African Americans and non-Hispanic whites

Variable	1	2	3	4	5	6	7	8	9
African Americans									
1. Sex	—								
2.Age	.06	—							
3. Study site	−.03	.12	—						
4. Education	−.16	.06	41**	—					
5. Income	−.19	−02	.30*	49**	—				
6. CES-D	.13	−.11	−29*	− 32**	−.29*	—			
7. WOMAC-pain	−.03	.02	−31*	−20	−.15	.39**	—		
8. EOD frequency	.03	−05	−.02	.19	−.13	−.04	−03	—	
9. TMRS	−02	−22	−.05	.06	.01	.05	−14	−24*	—
10. HPTo	.21	−.24*	−.04	.01	.10	.02	.06	−26*	.12
Non-Hispanic whites									
1. Sex	—								
2. Age	−.09	—							
3. Study site	−.01	.23	—						
4. Education	−.16	.11	.20	—					
5. Income	−.13	−.16	.05	.27*	—				
6. CES-D	−18	−.19	−.04	−01	.16	—			
7. WOMAC-pain	−.15	−.01	−.13	−16	.08	.50**	—		
8. EOD frequency	−.06	−.04	−.09	.23	.11	−.11	.14	—	
9. TMRS	−.07	−.01	−.07	.28*	..21	−.04	.01	−.03	—
10. HPTo	47**	−.25*	−.05	−01	−.01	−.01	−.15	−.06	−.04

*=p < .05,

**=p < .01

Note: Race coded 0 = African Americans, 1 = non-Hispanic whites; Sex coded 0 = women, l=men; Study site coded 0= Elonda, 1 = Alabama-Birmingham; Education coded 0 = completed high school orless, 1 = at least some college, Income coded 0 = below the poverty line, 1 = above the poverty line, CES-D = Center for Epidemiological Studies Depression Scale, WOMAC-pain = Western Ontario and

McMaster Universities Index of Osteo arthritis, pain subscale; EOD frequency = Experiences of Discrimination Scale, frequency of occurrences; TMRS =Trust in Medical Researchers Scale; HPTh = heat pain threshold; HPTo = heat pain tolerance.

Table 3

Hierarchical regressions examining whether perceived racial discrimination predicts heat pain tolerance among African Americans and non-Hispanic whites

Variable	African Americans				non-Hispanic whites			
	β	*t*	R^2	ΔR^2	β	*t*	R^2	ΔR^2
Step 1			0.13	0.13			0.27	0.27**
Sex	0.25*	2.06			0.45**	4.05		
Age	−0.25*	−2.07			−0.21	−1.77		
Study site	−0.05	−0.40			−0.01	−0.12		
Education	0.01	0.09			0.10	0.79		
Income	0.15	1.07			−0.01	−0.06		
Step 2			0.14	0.01			0.28	0.01
CES-D	−0.05	−0.33			0.10	0.73		
WOMAC-pam	0.11	0.78			−0.12	−0.85		
Step 3			0.22	0.08*			0.29	0.01
EOD frequency	−0.30*	−2.43			−0.04	−0.35		

*=$p < 0.05$,

**=$p < .01$

Note: CES-D = Center for Epidemiological Studies Depression Scale, WOMAC-pain = Western Ontario and McMaster Universities Index of Osteoarthritis, pain subscale; EOD frequency = Experiences of Discrimination Scale, frequency of occurrences; sex coded 0 = women, 1 = men; Study site coded 0 = Florida, 1 = Alabama-Birmingham; Education coded 0 = completed high school or less, 1 = at least some college; Income coded 0 = below the poverty line, 1 = above the poverty line.

Table 4

Hierarchical regressions examining whether mistrust of medical researchers predicts heat pain tolerance among African Americans and non-Hispanic whites

Variable	African Americans				non-Hispanic whites			
	β	*t*	R^2	ΔR^2	β	*t*	R^2	ΔR^2
Step 1			0.13	0.13			0.27	0.27**
Sex	0.25*	2.06			0.45**	4.05		
Age	−0.25*	−2.07			−0.21	−1.77		
Study site	−0.05	−0.40			−0.01	−0.12		
Education	0.01	0.09			0.10	0.79		
Income	0.15	1.07			−0.01	−0.06		
Step 2			0.14	0.01			0.28	0.01
CES-D	−0.05	−0.33			0.10	0.73		
WOMAC-pam	0.11	0.78			−0.12	−0.85		
Step 3			0.15	0.01			0.29	0.01
TMRS	0.09	0.67			−0.03	−0.24		

* $=p < 0.05$,

** $=p < .01$

Note: CES-D = Center for Epidemiological Studies Depression Scale; WOMAC-pain = Western Ontario and McMaster Universities Index of Osteoarthritis, pain subscale, TMRS = Trust in Medical Researchers Scale, sex coded 0 = women, 1 = men, Study site coded 0 = Florida, 1 = Alabama-Birmingham; Education coded 0 = completed high school or less, 1 = at least some college; Income coded 0 = below the poverty line, 1 = above the poverty line.