Comprehensive Review

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# Racial and ethnic differences in experimental pain sensitivity: systematic review and meta-analysis

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**Abstract**

Our objective was to describe the racial and ethnic differences in experimental pain sensitivity. Four databases (PubMed, EMBASE, the Cochrane Central Register of Controlled Trials, and PsycINFO) were searched for studies examining racial/ethnic differences in experimental pain sensitivity. Thermal–heat, cold–pressor, pressure, ischemic, mechanical cutaneous, electrical, and chemical experimental pain modalities were assessed. Risk of bias was assessed using the Agency for Healthcare Research and Quality guideline. Meta-analysis was used to calculate standardized mean differences (SMDs) by pain sensitivity measures. Studies comparing African Americans (AAs) and non-Hispanic whites (NHWs) were included for meta-analyses because of high heterogeneity in other racial/ethnic group comparisons. Statistical heterogeneity was assessed by subgroup analyses by sex, sample size, sample characteristics, and pain modalities. A total of 41 studies met the review criteria. Overall, AAs, Asians, and Hispanics had higher pain sensitivity compared with NHWs, particularly lower pain tolerance, higher pain ratings, and greater temporal summation of pain. Meta-analyses revealed that AAs had lower pain tolerance (SMD: −0.90, 95% confidence intervals [CIs]: −1.10 to −0.70) and higher pain ratings (SMD: 0.50, 95% CI: 0.30–0.69) but no significant differences in pain threshold (SMD: −0.06, 95% CI: −0.23 to 0.10) compared with NHWs. Estimates did not vary by pain modalities, nor by other demographic factors; however, SMDs were significantly different based on the sample size. Racial/ethnic differences in experimental pain sensitivity were more pronounced with suprathreshold than with threshold stimuli, which is important in clinical pain treatment. Additional studies examining mechanisms to explain such differences in pain tolerance and pain ratings are needed.

**Keywords:** Racial/ethnic differences, Pain sensitivity, Meta-analysis, Systematic review

## 1. Introduction

Chronic pain is a major health problem in the United States, and over 116 million Americans are currently affected.[35] It is reported that there are more than 70 million annual visits to health care providers at a cost more than $600,000 million per year in medical treatment and lost work productivity.[35] Also, patients with chronic pain and their families suffer from intangible costs related to pain, such as decreased quality of life and interpersonal stresses.[31]

Racial/ethnic minorities experience greater adverse effects caused by chronic pain, such adverse effects may include that they have lower quality of life,[27] higher pain anxiety and depressive symptoms,[20,27,32] higher limitation of activity and work,[5] and higher levels of disability.[54,65] Disparities related to pain management in the United States have been reported; racial/ethnic minorities received lower quality of pain care than non-Hispanic whites (NHWs) in acute, chronic, cancer, and palliative pain care across the lifespan and treatment settings.[4] Low socioeconomic status, lack of health insurance, limited or delayed access to care/medication, and patient–health care provider communication issues have been reported to be associated with racial/ethnic chronic pain disparities.[27,46,59]

Studies examining racial/ethnic differences in clinical pain have documented greater levels of clinical pain in racial/ethnic minorities compared with NHWs for various painful conditions, including joint pain, migraine headache, jaw pain, or arthritis.[15,23,24] Using a representative sample in the United States, Riskowaski[60] reported higher rates of acute pain in African Americans (AAs) and Hispanics compared with NHWs.

Although there is no consensus regarding the underlying mechanisms to explain the racial/ethnic group differences in clinical pain, several studies have found significant associations between experimental pain sensitivity and clinical pain. Higher experimental pain sensitivity was associated with higher clinical pain sensitivity in older adults with knee osteoarthritis (OA).[12] Lower ischemic pain tolerance in AAs compared with NHWs was associated with higher chronic pain in AA patients with noncancer chronic pain conditions.[15] Temporal summation (TS) of mechanical pain predicted greater clinical pain ratings in adults with knee OA.[24] Differences in central pain-inhibitory mechanisms (eg,

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conditioned pain modulation [CPM]) have been reported to be associated with racial/ethnic differences in clinical pain reports.[9]

A view of pain as a composite of 3 interdependent components—sensory–discriminative, cognitive–evaluate, and affective–motivational features—was proposed by Melzack and Wall and has become a dominant paradigm in the pain and pain management fields.[21] Pain threshold and pain intensity ratings are commonly considered indicative of the sensory–discriminative feature of pain, whereas tolerance and ratings of unpleasantness are considered indicative of the affective–motivational features of pain. It has been reported that sensory–discriminative components of pain vary relatively little across racial/ethnic groups, whereas affective–motivational components of pain are more sensitive to racial/ethnic differences.[16,60] Taken together, these results suggest that racial/ethnic differences in experimental pain sensitivity could contribute to the racial/ethnic differences in reported clinical pain.[15]

Most previous studies have focused on comparing AAs vs NHWs, as noted previously,[56] leading to a limited understanding of differences in experimental pain sensitivity among other racial/ethnic groups. Multiracial Americans, Asians, and Hispanics are rapidly growing populations in the United States,[66] making it increasingly relevant to examine pain sensitivity in multiple racial/ethnic groups. Therefore, the purpose of this study was to review the literature evaluating differences in experimental pain sensitivity among multiple racial/ethnic groups.

## 2. Methods

### 2.1. Search strategy and data sources

A systematic review of the literature was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[41,48] Search strategies were developed and adapted for PubMed, EMBASE (Elsevier), the Cochrane Central Register of Controlled Trials (Cochrane Library), and PsycINFO (EbscoHOST). Three categories of terms (pain, race/ethnicity, and experimental modalities and measures) were identified and combined to retrieve articles that included at least 1 term from each group. Both subject headings and free-text searching were used in all databases. Explosion, which applies all narrower terms underneath the subject heading automatically, was used to ensure a comprehensive search of ethnic and racial groups. No limits were applied for date or language in the initial search. The full search strategy for PubMed is provided in Appendix I (available online as supplemental digital content at http://links.lww.com/PAIN/A351).

Inclusion criteria for articles were as follows: full-text, published, peer-reviewed, English-language studies, studies of experimental pain sensitivity, published between January 2000 and February 2016, and limited to human subjects. Exclusion criteria were studies that did not use any type of experimental pain stimuli to evoke pain or did not compare pain sensitivity measures by racial/ethnic groups.

Two authors (H.J.K. and G.S.Y.) independently reviewed all retrieved titles after duplicates were removed. Selected abstracts were reviewed by the 2 reviewers independently, and full-text articles were selected on agreement that the article met the inclusion and exclusion criteria. Data extraction was conducted by one reviewer (H.J.K.) with a self-developed structured codebook and confirmed by the other reviewer (G.S.Y.) (**Fig. 1**).

Risk of bias in reporting racial/ethnic differences in experimental sensitivity in individual studies was assessed based on the criteria from the Agency for Healthcare Research and Quality (AHRQ) guideline. The Agency for Healthcare Research and Quality developed quality assessment criteria of individual studies according to the study design. The assessment criteria for nonexperimental design studies include sample size, methods for selecting participants, methods for measuring exposure variables, methods to deal with design-specific issues such as recall or interviewer bias, and analytical methods to control for confounding factors.[1] After assessment of individual criteria, ratings of "good," "fair," or "poor" can be assigned. Because we focused on racial/ethnic differences in experimental pain sensitivity for this review, most of the studies retrieved were those that used similar study design and methodology (eg, experimental pain sensitivity measurements in a laboratory setting, convenience sampling), and included multiple racial/ethnic samples. Therefore, 4 items were evaluated for each article: sample size ($\geq$100 vs $<$100), clear definition of the racial/ethnic group (provided vs unprovided), description of a standardized study protocol (provided vs unprovided), and control of confounding factors (yes vs no). Total scores ranged from 0 to 4, with a smaller number indicating a higher risk of bias. The quality of reviewed studies was assessed by the 2 reviewers independently (H.J.K. and G.S.Y.), and the ratings of each study were compared. Discrepancy was identified and discussed to arrive at agreement.

### 2.2. Data analysis

Included studies were classified by pain modality type and racial/ethnic group comparison (AAs vs NHWs, comparisons among other racial/ethnic groups). We conducted meta-analyses to estimate pooled standardized mean differences (SMDs) and 95% confidence intervals (CIs) between racial/ethnic groups to determine the magnitude of differences on pain sensitivity using Stata (version 13.1, StataCorp LP, College Station, TX). Tolerance, threshold, pain intensity ratings, and pain unpleasantness were examined and compared between the 2 groups (AAs vs NHWs). If

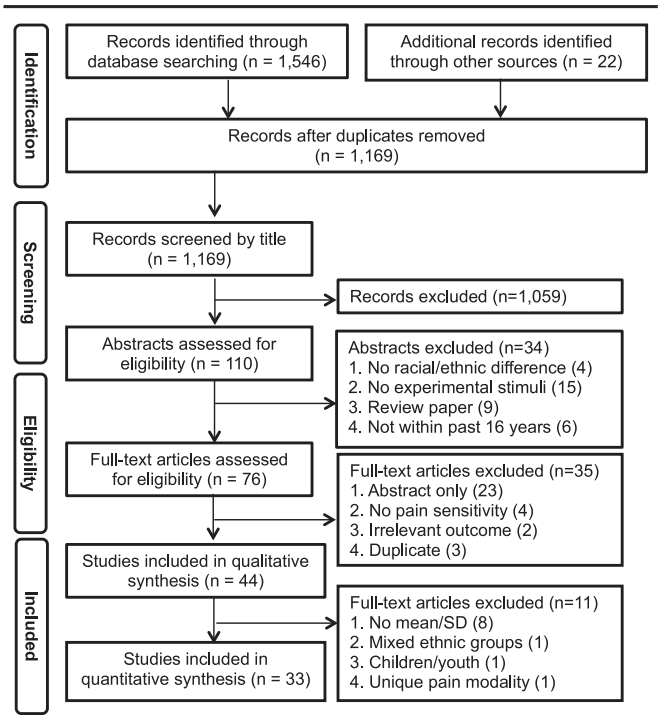


**Figure 1.** Flow diagram for review of studies of racial/ethnic differences in experimental pain sensitivity.

**Table 1**

**Studies examining racial/ethnic differences in thermal–cold experimental pain models.**

| Authors | Sample size | Sample characteristics | % (F) | ROB+ (0-4) | Simulation site | Method | Threshold | Tolerance | Ratings |
|---|---|---|---|---|---|---|---|---|---|
| Comparing AA and NHW | | | | | | | | | |
| Campbell et al.[7] | 120 (AA = 62, NHW = 58) | Young healthy adults | 54 | 4 | Left hand | Cold-pressor task (5°C) | No difference | NHW > AA | |
| Cruz-Almeida et al.[12] | 267 (AA = 120, NHW = 147) | With knee OA, aged from 45 to 85 | 63 | 4 | Hand | Cold-pressor task (16, 12, 8°C) | No difference | | AA > NHW (at 16 and 12°C, no difference at 8°C) |
| Fabian et al.[17] | 64 (AA = 11, API = 15, NHW = 26) | Young healthy adults | 61 | 2 | Hand | Cold-pressor task (4°C) | | No difference | AA = API > NHW |
| Forsythe et al.[19] | 155 (AA = 60, NHW = 95) | Healthy undergraduate students | 54 | 3 | Hand | Cold-pressor task (0-2°C) | | NHW > AA | No difference |
| Grewen et al.[29] | 48 (AA = 25, NHW = 23) | Premenopausal women | 100 | 3 | Hand | Cold-pressor task (4°C) | No difference | NHW > AA | |
| Hastie et al.[30] | 247 (AA = 81, NHW = 87, Hispanic = 79) | Young healthy adults | 52 | 3 | Hand | Cold-pressor task (5°C) | No difference | NHW > AA, Hispanic | NHW < AA, Hispanics |
| Klatzkin et al.[37] | 55 (AA = 32, NHW = 23) | Women with or without histories of depression | 100 | 2 | Hand | Cold-pressor task (4°C) | NHW > AA | NHW > AA | No difference |
| Kim et al.[36] | 617 (AA = 130, Hispanic = 59, API = 67, NHW = 344) | Healthy adults | 60 | 4 | Hand | Cold-pressor task (2-4°C) | | NHW (highest) > AA (lowest) | NHW (lowest) |
| Mechlin et al.[45] | 106 (AA = 51, NHW/other* = 55) | Healthy adults (18-47) | 53 | 3 | Hand | Cold-pressor task (4°C) | No difference | NHW/other > AA | |
| Mechlin et al.[44] | 84 (AA = 45, NHW = 39) | Young healthy adults | 51 | 3 | Hand | Cold-pressor task (4°C) | NHW > AA | NHW > AA | |
| Mechlin et al.[43] | 88 (AA = 44, NHW = 44) | Healthy adults (18-45) | 50 | 3 | Hand | Cold-pressor task | No difference | NHW > AA | No difference |
| Meints and Hirsh[47] | 190 (AA = 82, NHW = 108) | Healthy undergraduate students | 74 | 3 | Hand | Cold-pressor task (2°C) | No difference | NHW > AA | AA < NHW |
| Rahim-Williams et al.[57] | 206 (AA = 63, Hispanic = 61, and NHW = 82) | Healthy adults | 54 | 4 | Left hand | Cold-pressor task (5°C) | No difference | NHW > AA, Hispanics | |
| Riley et al.[58] | 191 (NHB = 53, and NHW = 138) | Middle-aged and older adults (range: 45-76) | 68 | 4 | Hand | Cold water immersion | No difference | | No difference |
| Weisse et al.[69] | 290 (NHW = 193, AA = 97) | Healthy undergraduate students | 55 | 3 | Hand | Cold-pressor task (0-2°C) | | | AA > NHW |
| Comparing other ethnicities | | | | | | | | | |
| Chan et al.[11] | 57 (FAA = 12, SAA = 21, EA = 24) | Undergraduate students living in the United States | 63 | 3 | Hand | Cold-pressor task (0.5-1°C) | No difference | SAA = EA > FAA | FAA > EA |
| Dawson and List[14] | 64 (Middle Easterners = 32, Swedes = 32) | Young healthy adults | 50 | 3 | Hand | Cold-pressor task (0-1°C) | No difference | Swedes > Middle Easterners | |
| Hsieh et al.[34] | 160 (Chinese = 80, EC = 80) | Healthy undergraduate students living in Canada | 52 | 4 | Hand | Cold-pressor task (2-3°C) | No difference | EC > Chinese | No difference |
| Hsieh et al.[33] | 184 (Chinese = 102, EC = 82) | Healthy undergraduate students living in Canada | 70 | 4 | Hand | Cold-pressor task | | | CM = ECM > EC |
| Nayak et al.[51] | 226 (In India = 119, in United States = 107) | Healthy college students, second or higher generation Americans and Indians in each country | 50 | 4 | Hand | Cold-pressor task (0-2°C) | | Indians in India > Americans in the United States | |

(*continued on next page*)

Table 1 (*continued*)

| Authors | Sample size | Sample characteristics | % (F) | ROB$^+$ (0-4) | Simulation site | Method | Threshold | Tolerance | Ratings |
|---|---|---|---|---|---|---|---|---|---|
| Rowell et al.[61] | 60 (NHW = 30, Asians = 30) | Healthy young adults living in the United States | 50 | 2 | Hand | Cold-pressor task (4°C) | NHW > Asians | NHW > Asians | No difference |
| Watson et al.[68] | 40 (white British = 20, South Asians = 20) | Working professional males living in the United Kingdom | 0 | 3 | Forearms | Contact cold | No difference | | |
| Yang et al.[70] | 58 (Chinese = 29, Danes = 29) | University students of each country | 52 | 3 | Bilaterally in the infraorbital and mental foramen | Contact cold | Chinese > Danes | | |

* Other included Indian, Asian, and Hispanic.
AA, African American; API, Asian/Pacific Islanders; CM, Chinese milieu-participants exposed to Chinese experimenters and language; EA, European American; EC, Euro-Canadian-participants exposed to the Euro-Canadian milieu only; ECM, European Canadian milieu-participants exposed to Euro-Canadian experimenters and English language; FAA, first-generation Asian American; HC, Hong Kong Chinese; MC, mainland Chinese; NHW, non-Hispanic white; OA, osteoarthritis; ROB$^+$, risk of bias; SAA, second-generation Asian American.

results of testing multiple body sites for a single pain modality were reported from a study, we selected the most commonly used measurement site (eg, forearm). Also, we chose the first measurement when there were multiple tests over time with a single modality. Heterogeneity across studies was identified by $I^2$ statistic ($I^2 \geq 50\%$); therefore, the random-effects model was used to get pooled SMDs.[6] To investigate heterogeneity, we performed subgroup analyses by sex (% of women), sample size, sample characteristics, and pain modalities using random-effects meta-regression models (DerSimonian and Laird method), with 95% CIs. We also conducted sensitivity analysis by excluding studies that did not provide definitions of race/ethnicity. The Egger tests of publication bias were performed to assess publication bias.[64] Publication bias indicates that small studies with a small or nonsignificant effect may be less likely to be published than studies reporting a large or significant effect.[63] $P < 0.05$ was considered statistically significant (2-tailed).

## 3. Results

The literature search yielded 1546 articles. Twenty-two articles were also found through Google Scholar and relevant bibliographies. After removal of duplicates, the title screening process identified 110 potentially eligible studies (**Fig. 1**). After abstracts were screened using the inclusion and exclusion criteria, 44 studies remained for qualitative synthesis.

In regard to the risk of bias of individual studies, most of the studies had a score of 3 or 4, indicating a low risk of bias. All of the studies had a standardized pain sensitivity measure protocol and had controlled for recognized confounding factors (eg, age, sex) in study designs or their analyses. However, more than half of the studies had sample sizes of less than 100, and several studies lacked information about how the researchers defined "race/ethnicity."

Racial/ethnic differences in experimental pain were evaluated using a wide range of stimulus modalities, including pressure, thermal-heat, cold-pressor, electric, ischemic, and chemical experimental pain (eg, capsaicin). Pain sensitivity has been assessed using a number of different outcome measures, including threshold and tolerance, and ratings of pain intensity and/or unpleasantness.

### *3.1. Qualitative synthesis*

The systematic review begins with a summary of pain sensitivity differences comparing AAs and NHWs, and followed by comparisons among other racial/ethnic groups for each pain modality. Forty-four studies were selected for qualitative synthesis.

### *3.2. Thermal pain*

#### *3.2.1. Cold pain stimuli*

Twenty-three studies examined racial/ethnic differences in experimental cold pain (**Table 1**). All studies used some form of the cold-pressor task in which subjects immersed their hand in circulating cold water for a determined period, except for 2 studies that used contact cold.[68,70] The sample size of the studies ranged from 40 to 617. The majority of study participants were young healthy adults, but one study examined patients with knee OA[12] and another examined women with or without histories of depression.[37] Fifteen studies compared AAs and NHWs. Nine studies reported no difference in cold pain threshold between the 2 groups, whereas 2 studies reported that NHWs

**Table 2**

**Studies examining racial/ethnic differences in thermal–heat experimental pain models.**

| Authors | Sample size | Sample characteristics | % (F) | ROB$^+$ (0-4) | Simulation site | Method | Threshold | Tolerance | Ratings |
|---|---|---|---|---|---|---|---|---|---|
| Comparing AA and NHW | | | | | | | | | |
| Campbell et al.[7] | 120 (AA = 62, NHW = 58) | Young healthy adults | 54 | 4 | Left ventral forearm | Contact heat | No difference | NHW > AA | AA > NHW |
| Cruz-Almeida et al.[12] | 267 (AA = 120, NHW = 147) | With knee OA, aged from 45 to 85 | 63 | 4 | Knee and forearm | Contact heat | NHW > AA | NHW > AA | |
| Glover et al.[23] | 94 (AA = 45, NHW = 49) | With symptomatic knee OA, middle-aged and older adults | 74 | 2 | Knee and forearm | Contact heat | NHW > AA (forearm only) | NHW > AA | |
| Goodin et al.[25] | 130 (AA = 67, NHW = 63) | Older adults with symptomatic knee OA | 77 | 3 | Index knee and ipsilateral ventral forearm | Contact heat | | NHW > AA | |
| Goodin et al.[24] | 225 (AA = 122, NHW = 103) | With knee OA, aged 45 y and above | 68 | 4 | Index knee and ipsilateral volar forearm | Contact heat | | | AA > NHW |
| Grewen et al.[29] | 48 (AA = 25, NHW = 23) | Premenopausal women | 100 | 3 | Volar forearms | Contact heat | No difference | NHW > AA | |
| Hastie et al.[30] | 247 (AA = 81, NHW = 87, Hispanic = 79) | Young healthy adults | 52 | 3 | Ventral forearm | Contact heat | No difference | No difference | No difference |
| Kim et al.[36] | 617 (AA = 130, Hispanic = 59, API = 67, NHW = 344) | Healthy adults | 60 | 4 | Ventral forearm | Contact heat | | | API > AA, Hispanic, NHW |
| Klatzkin et al.[37] | 55 (AA = 32, NHW = 23) | Women with or without histories of depression | 100 | 2 | Volar forearm | Contact heat | No difference | No difference | AA > NHW |
| Lu et al.[42] | 214 (NHW = 98, Hispanic = 58, AA = 34, and Asian = 24) | Healthy children (range: 8-18) | 49 | 3 | Both volar forearms | Radiant heat | | No difference | NHW = Asian > AA |
| Mechlin et al.[45] | 106 (AA = 51, NHW/other* = 55) | Healthy adults (range: 18-47) | 53 | 3 | Left volar forearm | Contact heat | No difference | NHW/other > AA | |
| Mechlin et al.[44] | 84 (AA = 45, NHW = 39) | Young healthy adults | 51 | 3 | Left volar forearm | Contact heat | No difference | NHW > AA | |
| Morris et al.[49] | 78 (AA = 40, NHW = 38) | Healthy youth (range: 10-17) | 51 | 2 | Nondominant ventral forearm | Contact heat | | | AA > NHW |
| Riley et al.[58] | 191 (AA = 53, and NHW = 138) | Middle-aged and older adults (range: 45-76) | 68 | 4 | Forearms and knee | Contact heat | No difference | NHW > AA | No difference |
| Rahim-Williams et al.[57] | 206 (AA = 63, Hispanic = 61, and NHW = 82) | Healthy adults | 54 | 4 | Ventral forearm | Contact heat | No difference | NHW > AA, Hispanic | |
| Sheffield et al.[62] | 51 (AA = 24, NHW = 27) | Healthy adults | 49 | 3 | Right volar forearm | Contact heat | | | AA > NHW |
| Comparing other ethnicities | | | | | | | | | |
| Watson et al.[68] | 40 (white British = 20, South Asians = 20) | Working professional males living in the United Kingdom | 0 | 3 | Forearms | Contact heat | White British > South Asians | | South Asians > white British |
| Yang et al.[70] | 58 (Chinese = 29, Danes = 29) | University students living in each country | 52 | 3 | Bilaterally in the infraorbital and mental foramen | Contact heat | Danes > Chinese | | |

* Other included Indian, Asian, and Hispanic.

AA, African American; AA, African American; API, Asian/Pacific Islanders; NHW, non-Hispanic white; OA, osteoarthritis; ROB$^+$, risk of bias.

**Table 3**

**Studies examining racial/ethnic differences in mechanical–pressure experimental pain models.**

| Authors | Sample size | Sample characteristics | % (F) | ROB$^{+}$ (0-4) | Simulation site | Method | Threshold | Tolerance | Ratings |
|---|---|---|---|---|---|---|---|---|---|
| Comparing AA and NHW | | | | | | | | | |
| Cruz-Almeida et al.[12] | 267 (AA = 120, NHW = 147) | With knee OA, aged from 45 to 85 | 63 | 4 | Knee, ipsilateral quadriceps, trapezius, and dorsal forearm | PA | NHW > AA (only knee) | | |
| Glover et al.[23] | 94 (AA = 45, NHW = 49) | With symptomatic knee OA, middle-aged and older adults | 74 | 2 | Knee and forearm | PA | NHW > AA | | |
| Goodin et al.[26] | 149 (AA = 28, Asian = 35, NHW = 86) | Healthy college students | 52 | 3 | Dorsal forearm and ipsilateral trapezius | PA | forearm: no difference, Trapezius: NHW = Asian > AA | | |
| Hastie et al.[30] | 247 (AA = 81, NHW = 87, Hispanic = 79) | Young healthy adults | 52 | 3 | Bilateral upper trapezius, masseter, and ulna | PA | No difference | | |
| Rahim-Williams et al.[57] | 206 (AA = 63, Hispanic = 61, and NHW = 82) | Healthy adults | 54 | 4 | Left upper trapezius, left masseter | PA | No difference | | |
| Riley et al.[58] | 191 (AA = 53, and NHW = 138) | Middle-aged and older adults (range: 45-76) | 68 | 4 | Medial joint, lateral joint, quadricep, trapezius, epicondyle | PA | No difference | | |
| Lu et al.[42] | 214 (NHW = 98, Hispanic = 58, AA = 34, and Asian = 24) | Healthy children (range: 8-18) | 49 | 3 | Middle and index finger of each hand | Analgesy-Meter | | No difference | No difference |
| Comparing other ethnicities | | | | | | | | | |
| Alabas et al.[2] | 175 (Libyan = 124, white British = 51) | Healthy undergraduate students living in each country | 50 | 4 | 1st interosseous muscle | PA | Libyans > white British | | |
| Al-Harthy et al.[3] | 244 (Saudis = 41, Swedes = 41, Italians = 42 for each case/control group) | Female, temporomandibular disorder case/control | 100 | 4 | Right masseter and temporalis muscle | PA | Saudis > Swedes | Swedes > Italians | |
| Dawson and List[14] | 64 (Middle Easterners = 32, Swedes = 32) | Young healthy adults | 50 | 3 | Right masseter muscle | PA | No difference | Swedes > Middle Easterners | |
| Gazerani and Arendt-Nielsen[22] | 32 (South Indians = 16, white European Danes = 16) | Healthy university students living in Denmark | 0 | 1 | Forehead | PA (before and after capsaicin) | White European Danes > South Indians | | |
| Komiyama et al.[38] | 88 (Belgian = 44, Japanese = 44) | University students and staff living in each country | 50 | 3 | Masseter, thenar muscle | PA | Belgian > Japanese | Belgian > Japanese | Belgian > Japanese |
| Komiyama et al.[39] | 56 (Belgian = 28, Japanese = 28) | University students and staff living in each country | 50 | 3 | Masseter muscle | PA | No difference | | |
| Yang et al.[70] | 58 (Chinese = 29, Danes = 29) | University students living in each country | 52 | 3 | Masseter muscle | PA | Danes > Chinese | | |

AA, African American; NHW, non-Hispanic whites; OA, osteoarthritis; PA, pressure algometer; ROB$^{+}$, risk of bias.

**Table 4**

**Studies examining racial/ethnic differences in mechanical–ischemic experimental pain models.**

| Authors | Sample size | Sample characteristics | % (F) | ROB+ (0-4) | Simulation site | Method | Threshold | Tolerance | Ratings |
|---|---|---|---|---|---|---|---|---|---|
| Alabas et al.[2] | 175 (Libyan = 124, white British = 51) | Healthy undergraduate students living in each country | 50 | 3 | 1st interosseous muscle | SETT | | | Libyans > white British |
| Campbell et al.[10] | 135 (AA = 72, NHW = 63) | Young adults | 36 | 3 | Dominant upper arm | SETT | | | AA > NHW |
| Campbell et al.[7] | 120 (AA = 62, NHW = 58) | Young healthy adults | 54 | 4 | Left arm | SETT | No difference | NHW > AA | |
| Das Gupta et al.[13] | 152 (Malay = 46, Chinese = 62, Indian = 44) | Healthy university students living in Malaysia | 55 | 3 | Arm | SETT | | No difference | |
| Edwards et al.[15] | 337 (AA = 68, NHW = 269) | Patients with chronic pain | 40 | 3 | Arm | SETT | | NHW > AA | AA > NHW |
| Grewen et al.[29] | 48 (AA = 25, NHW = 23) | Premenopausal women | 100 | 3 | Arm | SETT | No difference | No difference | |
| Hastie et al.[30] | 247 (AA = 81, NHW = 87, Hispanic = 79) | Young healthy adults | 52 | 3 | Arm | SETT | NHW < AA, Hispanics | NHW > AA, Hispanics | |
| Klatzkin et al.[37] | 55 (AA = 32, NHW = 23) | Women with or without histories of depression | 100 | 2 | Arm | SETT | No difference | NHW > AA | No difference |
| Mechlin et al.[45] | 106 (AA = 51, NHW/other* = 55) | Healthy adults (18-47) | 53 | 3 | Arm | SETT | No difference | NHW/other > AA | |
| Mechlin et al.[44] | 84 (AA = 45, NHW = 39) | Young healthy adults | 51 | 3 | Arm | SETT | No difference | NHW > AA | |
| Mechlin et al.[43] | 88 (AA = 44, NHW = 44) | Healthy adults (18-45) | 50 | 3 | Arm | SETT | No difference | NHW > AA | No difference |
| Palit et al.[52] | 42 (Native Americans = 22, NHW = 20) | Healthy adults | 36 | 3 | Arm | SETT | Native Americans > NHW | Native Americans > NHW | |
| Rahim-Williams et al.[57] | 206 (AA = 63, Hispanic = 61, and NHW = 82) | Healthy adults | 54 | 4 | Left arm | SETT | No difference | No difference | |

* Other included Indian, Asian, and Hispanic.

AA, African American; EA, East Asian; NHW, non-Hispanic white; ROB+, risk of bias; SETT, submaximal effort tourniquet test.

demonstrated higher thresholds than did AAs.[37,44] In contrast, 10 of 11 studies comparing cold pain tolerance between AAs and NHWs found that NHWs had higher cold pain tolerance than did AAs, except one study reporting no difference.[17] Suprathreshold cold pain ratings were measured during the cold pressure task (eg, at 30-second intervals) or at the end of the task for some studies. Four of 10 studies indicated that there was no racial/ethnic difference in suprathreshold pain ratings, whereas 5 studies indicated that AAs had higher pain ratings than did NHWs for cold stimuli and one study reported the opposite result.[47]

Regarding other race/ethnic groups, 10 studies included Asians and 3 studies included Hispanics (**Table 1**). Hispanics showed lower tolerance level and higher pain ratings than did NHWs for all 3 studies.[30,36,57] Results from studies involving Asian groups were more varied. The ethnicity of Asians and comparison groups was diverse across the studies; 4 studies compared Asians, including Chinese or Koreans, with NHWs,[11,17,61,68] and 3 studies specifically explored Chinese compared with Danes[70] and with European Canadian.[33,34] Nayak et al.[51] examined second-generation Americans with various racial/ethnic backgrounds in the United States and compared them with Indians in India, and Dawson and List[14] compared Middle Easterners with Swedes. Four of 6 studies that examined cold pain threshold indicated no difference, and 4 of 6 studies that examined cold pain tolerance indicated that Asians had a lower pain tolerance than did the comparison groups. Three of 5 studies that examined suprathreshold pain ratings reported higher pain ratings in Asians compared with various racial/ethnic groups (mostly Western).

Experimental cold pain stimulation (mostly the cold-pressor task) was the most commonly used method in studies of racial/ethnic differences in experimental pain sensitivity. Overall, racial/ethnic minorities had higher sensitivity measured with tolerance and pain ratings compared with NHWs, whereas differences in threshold were only infrequently observed.

### *3.2.2. Heat pain stimuli*

Eighteen studies examined racial/ethnic differences in experimental heat pain (**Table 2**). All of the studies used some form of contact heat with the exception of one study that used radiant heat.[42] Contact heat stimuli were commonly delivered using a computer-controlled thermode (eg, Medoc Thermal Sensory Analyzer). The sample size of the studies ranged from 40 to 617. Sample characteristics varied, including patients with knee OA,[12,23–25] women with/without depression history,[37] healthy children,[42] healthy youth,[49] and middle-aged and older adults.[12,23–25,58] Sixteen studies compared AAs and NHWs, 10

**Table 5**

**Studies examining racial/ethnic differences in mechanical cutaneous experimental pain models.**

| Authors | Sample size | Sample characteristics | % (F) | ROB+ (0-4) | Simulation site | Method | Threshold | Tolerance | Ratings |
|---|---|---|---|---|---|---|---|---|---|
| Cruz-Almeida et al.[12] | 267 (AA = 120, NHW = 147) | With knee OA, aged from 45-85 | 63 | 4 | Patella and back of the ipsilateral hand | Calibrated nylon monofilament prick | | | AA > NHW |
| Goodin et al.[24] | 225 (AA = 122, NHW = 103) | With knee OA, aged 45 y and older | 68 | 4 | Patella and back of the ipsilateral hand | Calibrated nylon monofilament prick | | | AA > NHW |
| Komiyama et al.[38] | 88 (Belgian = 44, Japanese = 44) | University students and staff living in each country | 50 | 3 | Cheek skin, Maxillary gingiva, tongue tip, thenar skin | Filament-prick | Belgian > Japanese (cheek, tongue tip and thenar skin) | | Belgian > Japanese (Maxillary gingiva) |
| Komiyama et al.[38] | 88 (Belgian = 44, Japanese = 44) | University students and staff living in each country | 50 | 3 | Cheek skin, maxillary gingiva, tongue tip, thenar skin | Tactile detection | Belgian > Japanese (cheek and thenar skin) | No difference | No difference |
| Komiyama et al.[39] | 56 (Belgian = 28, Japanese = 28) | University students and staff living in each country | 50 | 3 | Masseter muscle | Tactile detection and filament-prick pain | Belgian > Japanese | | |
| Riley et al.[58] | 191 (AA = 53, and NHW = 138) | Middle-aged and older adults (range: 45-76) | 68 | 4 | Patella and the dorsal surface of the hand | Calibrated nylon monofilament punctuate | | | AA > NHW |
| Yang et al.[70] | 58 (Chinese = 29, Danes = 29) | University students living in each country | 52 | 3 | Bilaterally in the infraorbital and mental foramen | Pinprick stimuli | Danes > Chinese | | |

AA, African American; NHW, non-Hispanic white; OA, osteoarthritis; ROB+, risk of bias.

of which compared heat pain threshold between the 2 groups. Eight of 10 studies indicated no difference in heat pain threshold between AAs and NHWs, whereas 2 studies of patients with OA[12,23] reported higher thresholds for NHWs vs AAs. Nine of 12 studies reported higher heat pain tolerance in NHWs than AAs. With respect to suprathreshold heat pain ratings, 5 studies showed higher pain ratings in AAs than in NHWs, 2 studies found no difference, and 1 study found a reverse association in children,[42] indicating higher pain ratings in NHWs than in AAs.

For other race/ethnic groups, 4 studies included Hispanics[30,36,42,57] and 4 studies included Asians.[36,42,68,70] No difference was found in heat pain threshold between Hispanics and NHWs,[30,57] whereas one study reported lower pain tolerance in Hispanics.[57] For Asians, 2 studies reported that Asians had lower heat pain thresholds than did NHWs.[68,70] One study evaluated heat pain tolerance and found no difference among AA, Asian, Hispanic, and NHW children.[42] With respect to suprathreshold heat pain ratings, Asians produced higher pain ratings compared with Hispanics, AAs, and HNWs,[36] and compared with white British[68] and with AAs.[42]

Heat pain stimulation was the second most commonly used modality in studies of racial/ethnic differences in experimental sensitivity—frequently using contact heat thermodes. Most studies compared AAs and NHWs and reported higher sensitivity in AAs measured by tolerance and pain ratings, but no differences in threshold among healthy participants.

### 3.3. Mechanical pain

#### 3.3.1. Pressure pain stimuli

Fourteen studies examined racial/ethnic difference in pressure pain sensitivity (**Table 3**). All of the studies used pressure algometry (eg, Medoc/Somedic digital pressure algometer) with the exception of one study that used an analgesy-meter, which is the device often used to perform paw pressure experiments in rodents.[42] The sample size of the studies ranged from 32 to 267. Studies included young healthy adults, patients with knee OA,[12,23] healthy children,[42] females with temporomandibular disorder,[3] and middle-aged and older adults.[12,23,58] Seven studies compared AAs and NHWs, 6 of which measured threshold. Three of 6 studies reported no difference in pressure pain threshold between AAs and NHWs, whereas the other 3 studies found lower thresholds for AAs. Only one study examined pressure pain tolerance and reported no difference among AA, Asian, Hispanic, and NHW children. This study also evaluated pressure pain ratings and found no difference among the groups.[42]

For other race/ethnic groups, 3 studies included Hispanics[30,42,57] and 5 studies included Asians.[25,38,39,42,70] No difference in pressure pain threshold was found between Hispanics and other racial/ethnic groups (AAs and NHWs).[30,57] For studies of Asian groups, Goodin et al.[26] found higher pressure pain threshold in Asians than in AAs. Several studies evaluated pressure pain sensitivity differences between specific ethnic groups. Yang et al.[70] compared pressure pain threshold between Chinese and Danes and found that Danes had higher threshold than did Chinese. Komiyama et al. compared Japanese with Belgians in 2 studies.[38,39] Japanese had lower pressure pain threshold and tolerance than did Belgians in one study, but no differences were found for pain threshold in the second study.[39] Alabas et al.[2] examined pressure pain threshold difference between Libyans and white British and found that Libyans had higher threshold than did white British. Gazerani and Arendt-Nielsen[22] examined pressure pain threshold before and after capsaicin exposure and found higher pressure pain threshold in white European Danes than in South Indians both before and after capsaicin exposure. Two studies compared Middle Easterners with Swedes[3,14] and reported mixed results in pressure pain sensitivity.

Studies examining racial/ethnic differences in pressure pain sensitivity commonly used a pressure algometer, and most of the studies measured thresholds. Results were mixed by participant characteristics (eg, patients with OA) and ethnicities.

#### 3.3.2. Ischemic pain stimuli

Thirteen studies examined racial/ethnic differences in experimental ischemic pain (**Table 4**). These studies used the submaximal effort tourniquet test to induce ischemic pain, which induces pain by occluding a participant's arm using a blood pressure cuff. Although most of the participants of the studies were young healthy adults, one study was conducted with women with/without a history of depression.[37] Ten studies compared AAs and NHWs; overall, no differences were found for threshold, whereas lower tolerance levels were found in AAs. Two studies included Hispanics[30,57] and reported mixed results on differences in ischemic pain sensitivity. Alabas et al.[2] compared ischemic pain ratings between Libyans and white British and found that Libyans had higher pain ratings than did white British. Palit et al.[52] compared Native Americans with NHWs and reported higher threshold and tolerance in Native Americans than in NHWs.

#### 3.3.3. Mechanical cutaneous pain stimuli

Seven studies examined racial/ethnic differences in mechanical cutaneous pain (**Table 5**). The sample size of included studies ranges from 56 to 267. Mechanical cutaneous pain was induced using nylon monofilament stimulation to evaluate pricking pain threshold or suprathreshold pain ratings. Three studies compared AAs and NHWs[12,24,58] and reported higher pain ratings in AAs. Komiyama et al.[38,39] compared Japanese with Belgians, and found that Japanese had lower thresholds than did Belgians. Yang et al.[70] compared Chinese with Danes and found that Chinese had lower mechanical cutaneous pain threshold using pinprick stimuli than did Danes. Overall, the results from studies using mechanical cutaneous pain stimuli were mixed and sparse, and comparisons were made among particularly diverse ethnic groups.

### 3.4. Other pain modalities

#### 3.4.1. Chemical pain stimuli

Two studies examined racial/ethnic difference in chemical pain sensitivity using capsaicin (**Table 6**). Gazerani and Arendt-Nielsen[22] reported higher postcapsaicin pain ratings in South Indians compared with white European Danes. Wang et al.[67] studied differences of pain sensitivity among AAs, East Asians, Hispanics, and NHWs, evaluating heat pain threshold and suprathreshold pain ratings after capsaicin exposure. The authors reported that East Asians demonstrated the highest maximum intensity of postcapsaicin burning or pain sensation, followed by Hispanics, NHWs, and AAs; East Asians and Hispanics had significantly higher ratings compared with AAs.

**Table 6**

**Studies examining racial/ethnic differences in chemical and electrical experimental pain models.**

| Authors | Sample size | Sample characteristics | % (F) | ROB$^+$ (0-4) | Simulation site | Method | Threshold | Tolerance | Ratings |
|---|---|---|---|---|---|---|---|---|---|
| Chemical pain | | | | | | | | | |
| Gazerani and Arendt-Nielsen[22] | 32 (South Indians = 16, white European Danes = 16) | Healthy university students living in Denmark | 0 | 1 | Forehead | Capsaicin injection | | | South Indians > white European Danes |
| Wang et al.[67] | 40 (AA = 10, EA = 10, Hispanic = 10, and NHW = 10) | Healthy adults | 50 | 2 | forearms | Application of capsaicin | (Pre–post capsaicin changes) NHW, Hispanic > AA | | (Postcapsaicin) EA > AA, Hispanic > AA, AA = NHW |
| Electrical pain | | | | | | | | | |
| Al-Harthy et al.[3] | 244 (Saudis = 41, Swedes = 41, Italians = 42 for each group) | Female with temporomandibular disorder case/control | 100 | 4 | Thumb and index fingers on the right hand | Electrical stimulation | Saudis < Swedes, Saudis < Italians | Saudis > Italians, Swedes > Italians | |
| Campbell et al.[8] | 58 (AA = 29, NHW = 29) | Healthy young adults | 55 | 3 | Left biceps femoris muscle | Electrical stimulation | NHW > AA | | No difference |
| Dawson and List[14] | 64 (Middle Easterners = 32, Swedes = 32) | Young healthy adults | 50 | 3 | Thumb and index finger | Electrical stimulation | No difference | No difference | |
| Komiyama et al.[39] | 56 (Belgian = 28, Japanese = 28) | University students and staff living in each country | 50 | 3 | Masseter muscle | Electrical stimulation | Belgian > Japanese | | |
| Palit et al.[52] | 42 (Native Americans = 22, NHW = 20) | Healthy adults | 36 | 3 | Ipsilateral biceps femoris muscle, popliteal fossa, lateral epicondyle of the femur | Electrical stimulation | Native Americans > NHW | No difference | NHW > Native Americans |

AA, African American; EA, East Asian; NHW, non-Hispanic white; SETT, submaximal effort tourniquet test; ROB$^+$, risk of bias.

For pre–post capsaicin heat pain threshold changes, significant decreases were found in NHWs, East Asians, and Hispanics but not in AAs, and the magnitude of changes was greater in NHWs and Hispanics than in AAs.[67]

#### 3.4.2. Electrical pain stimuli

Five studies examined racial/ethnic differences in electrical pain (**Table 6**). Electrical pain was induced using a constant-current stimulator. Campbell et al.[8] reported that AAs demonstrated lower electrical pain threshold than did NHWs, and Komiyama et al.[39] reported that the Japanese demonstrated lower electrical pain threshold than did Belgians. Palit et al.[52] reported higher electrical pain thresholds for Native Americans compared with NHWs, whereas no difference was found in tolerance. Native Americans produced lower pain ratings than did NHWs for constant-current electrical stimuli.[52] Al-Harthy et al.[3] and Dawson and List[14] compared electrical pain threshold and tolerance among Saudis, Swedes, and Italians, and reported mixed results.

### 3.5. Pain unpleasantness

Eleven studies examined racial/ethnic differences in pain unpleasantness (**Table 7**). Most of the studies evoked cold pain using the cold-pressor task, and measured pain unpleasantness using a visual analogue scale. Greater pain unpleasantness was reported in AAs compared with NHWs in studies of healthy young adults,[7,10,30,69] whereas no differences was found in other studies.[19,43,58] One study of elderly adults with knee OA reported greater unpleasantness in AA compared with NHW.[12] In contrast, another study of healthy children reported greater unpleasantness in NHWs than in AAs and Hispanics. Alabas et al.[2] used pressure and ischemic pain and found that Libyans reported higher unpleasantness for pressure pain compared with British, but no difference for ischemic pain.

### 3.6. Temporal summation of pain

Seven studies examined racial/ethnic differences in TS of pain (**Table 8**). Brief painful pain stimuli are repetitively delivered to the skin at intervals at or less than 3 seconds. A gradual increase in subjective pain ratings is characteristic of temporal response to repetitive noxious stimuli, and this has been documented using many different stimulus modalities. Temporal summation reflects central nervous system temporal integration processes (often termed "wind-up") and is associated with C-fiber input (eg, second pain) more so than with A-delta fiber input (eg, first pain). Accordingly, TS of pain is commonly used to evaluate central nociception processing.[18] Overall, AAs demonstrated higher TS than did NHWs.[12,24,43,58] One study reported lower TS for healthy AA youth compared with NHW youth.[49] Yang et al.[70] found that

**Table 7**

**Studies examining racial/ethnic differences in pain unpleasantness.**

| Authors | Sample size | Sample characteristics | Pain stimuli | Method | Results |
|---|---|---|---|---|---|
| Alabas et al.[2] | 175 (Libyan = 124, white British = 51) | Healthy undergraduate students living in each country | Pressure and ischemic pain | VAS (0-100 mm) | Libyans > British for Pressure pain, no differences in Ischemic pain |
| Campbell et al.[7] | 120 (AA = 62, NHW = 58) | Young healthy adults | Cold pain | 0-20 box scales | AA > NHW |
| Campbell et al.[10] | 135 (AA = 72, NHW = 63) | Young adults | Ischemic pain | Standard VRS and Individualized VRS cards (unpleasant descriptors ordered from the least score of 1 to most severe-score of 13) | AA> NHW for Standard verbal rating scale, No difference for individualized verbal rating scale |
| Chan et al.[11] | 57 (FAA = 12, SAA = 21, EA = 24) | Undergraduate students living in the United States | Cold pain | VAS (15 cm long) | No difference |
| Cruz-Almeida et al.[12] | 267 (AA = 120, NHW = 147) | With knee OA, aged from 45 to 85 | Cold pain | Verbal rating (0-100) | AA > NHW (at 16 and 12°C, no difference at 8°C) |
| Forsythe et al.[19] | 155 (AA = 60, NHW = 95) | Healthy undergraduate students | Cold pain | VAS (10 cm) | No difference |
| Hastie et al.[30] | 247 (AA = 81, NHW = 87, Hispanic = 79) | Young healthy adults | Cold pain | 0-100 box scale | AA, Hispanic > NHW |
| Lu et al.[42] | 214 (NHW = 98, Hispanic = 58, AA = 34, and Asian = 24) | Healthy children (range: 8-18) | Heat and pressure pain | VAS (10 cm) | Hispanic < NHW = Asian for pressure pain, AA < NHW = Asian for Heat pain |
| Mechlin et al.[43] | 88 (AA = 44, NHW = 44) | Healthy adults (18-45) | Cold pain and ischemic pain | VAS (0-100) | No difference |
| Riley et al.[58] | 191 (NHB = 53, and NHW = 138) | Middle-aged and older adults (range: 45-76) | Cold pain | A scale from 0 to 100 | No difference |
| Weisse et al.[69] | 290 (NHW = 193, AA = 97) | Healthy undergraduate students | Cold pain | Gracely box scale (numeric 0–20 rating scale: neutral to very intolerable) | AA > NHW |

AA, African American; CPT, cold-pressor task; EA, European American; FAA, first-generation Asian American; NHW, non-Hispanic white; OA, osteoarthritis; SAA, second-generation Asian American; VAS, visual analogue scale; VRS, verbal rating scale.

**Table 8**

**Studies examining racial/ethnic differences in experimental pain models of temporal summation.**

| Authors | Sample size | Sample characteristics | Stimulation site | Method | Summation |
|---|---|---|---|---|---|
| Cruz-Almeida et al.[12] | 267 (AA = 120, NHW = 147) | With knee OA, aged from 45 to 85 | Knee and forearm | Contact heat | AA > NHW |
| Cruz-Almeida et al.[12] | 267 (AA = 120, NHW = 147) | With knee OA, aged from 45 to 85 | Knee, ipsilateral quadricepts, trapezius, and dorsal forearm | Pressure algometer | AA > NHW |
| Goodin et al.[24] | 225 (AA = 122, NHW = 103) | With knee OA, aged 45 y and older | Index knee and ipsilateral volar forearm | Contact heat | AA > NHW |
| Goodin et al.[24] | 225 (AA = 122, NHW = 103) | With knee OA, aged 45 y and older | Patella and back of the ipsilateral hand | Calibrated nylon monofilament prick | AA > NHW |
| Mechlin et al.[43] | 88 (AA = 44, NHW = 44) | Healthy adults (18-45) | Palm | Contact heat | AA > NHW |
| Morris et al.[49] | 78 (AA = 40, NHW = 38) | Healthy youth (range: 10-17) | Forearms | Contact heat | AA < NHW |
| Palit et al.[52] | 42 (Native Americans = 22, NHW = 20) | Healthy adults | Arm | Submaximal effort tourniquet test | No difference |
| Riley et al.[58] | 191 (AA = 53, NHW = 138) | Middle-aged and older adults (range: 45-76) | Forearms | Contact heat | No difference |
| Riley et al.[58] | 191 (AA = 53, NHW = 138) | Middle-aged and older adults (range: 45-76) | Knee | Contact heat | AA > NHW |
| Riley et al.[58] | 191 (AA = 53, NHW = 138) | Middle-aged and older adults (range: 45-76) | Medial joint, lateral joint, quadricep, trapezius, epicondyle | Pressure algometer | AA > NHW (Knee and Hand) |
| Yang et al.[70] | 58 (Chinese = 29, Danes = 29) | University students living in each country | Bilaterally in the infraorbital and mental foramen | Pinprick stimuli | Danes > Chinese |

AA, African American; NHW, non-Hispanic white; OA, osteoarthritis.

Danes showed higher TS than did Chinese. Another study did not show TS differences between Native Americans and NHWs.[52]

### 3.7. Conditioned pain modulation

Six studies compared racial/ethnic differences in CPM (**Table 9**). Conditioned pain modulation refers to reduced pain intensity perception for a test stimulus when also exposed to a painful conditioning stimulus.[50] Conditioned pain modulation is believed to reflect descending endogenous pain-inhibitory processes, initially called "diffuse noxious inhibitory control," serving to reduce nociceptive signaling originating from elsewhere on the body.[53] Diminished CPM was reported for AAs compared with NHWs in one study of healthy adults,[9] whereas another study reported no

**Table 9**

**Studies examining racial/ethnic differences in conditioned pain modulation.**

| Authors | Sample size | Sample characteristics | Stimulation site | Method | Conditioning stimulus | Conditioned pain modulation |
|---|---|---|---|---|---|---|
| Campbell et al.[9] | 57 (AA = 29, NHW = 28) | Healthy young adults | Right arm | Electric pain | Submaximal effort tourniquet procedure | Greater reductions in pain ratings in NHWs compared with AAs |
| Cruz-Almeida et al.[12] | 267 (AA = 120, NHW = 147) | With knee OA, aged from 45 to 85 | Left ventral forearm | Contact heat | Cold water immersion | No significant changes (pre–post) in NHWs, significant increase in pain ratings in AAs |
| Goodin et al.[26] | 149 (AA = 28, Asian = 35, NHW = 86) | Healthy young adults | Left dorsal forearm or left trapezius | Pressure algometer | Cold water immersion | Significant reductions in pain ratings; No significant difference in CPM effect across ethnic groups |
| Morris et al.[50] | 78 (AA = 40, NHW = 38) | Healthy youth (range: 10-17) | Nondominant forearm | Contact heat | Hot water immersion | Greater reductions in pain ratings in AAs than NHWs |
| Palit et al.[53] | 88 (AA = 44, NHW = 44) | Healthy adults (18-45) | Left ankle | Electric pain | Picture viewing (mutilation, neutral, and erotic) | NHWs: pain inhibition by erotica and pain facilitation by mutilation; Native Americans: pain inhibition by erotica, no disinhibition by mutilation |
| Riley et al.[58] | 191 (AA = 53, NHW = 138) | Middle-aged and older adults (range: 45-76) | Left forearm | Contact heat | Cold water immersion | No significant effect of the CPM manipulation in both groups |

AA, African American; CPM, conditioned pain modulation; NHW, non-Hispanic white; OA, osteoarthritis.

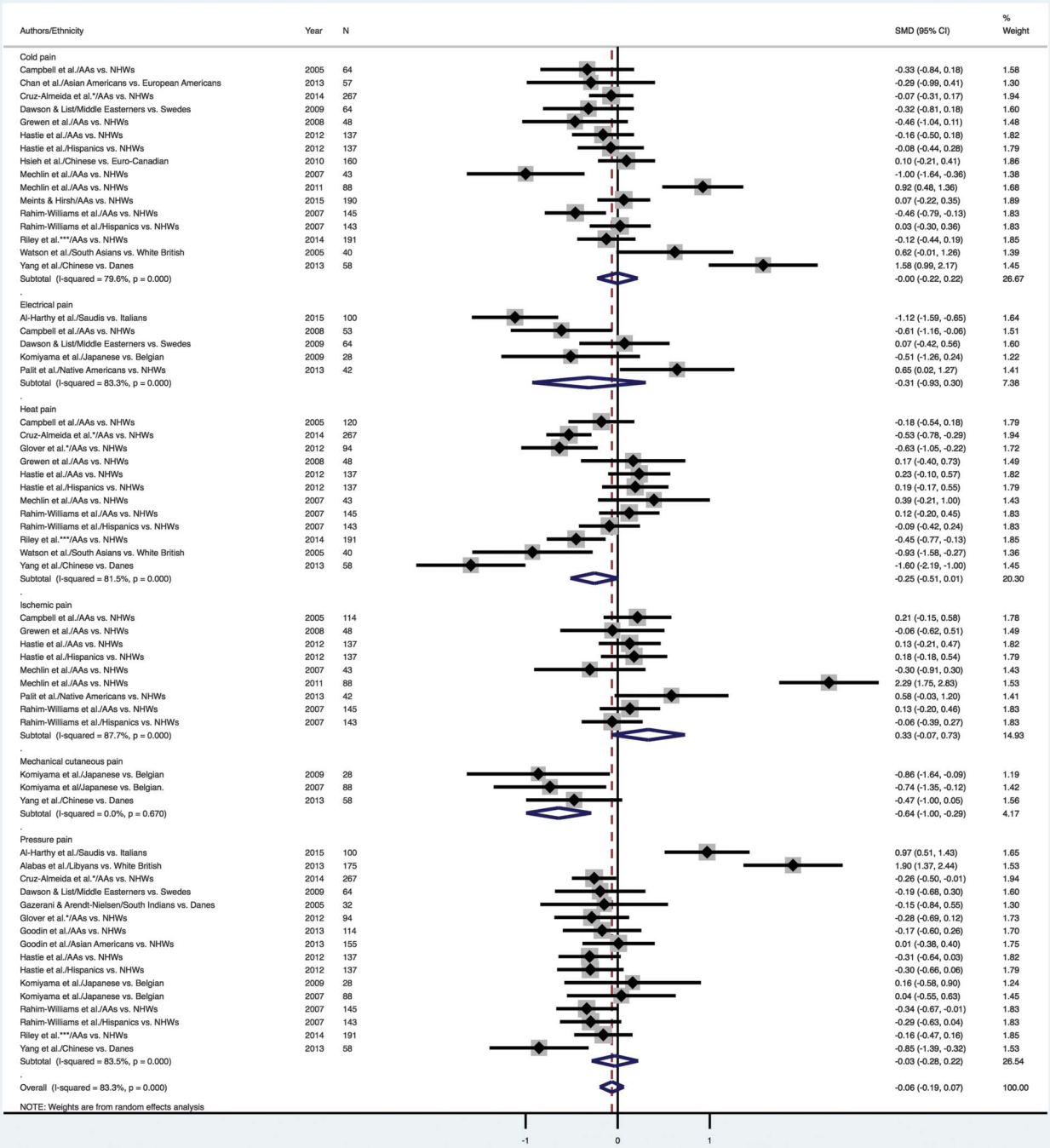


**Figure 2.** Meta-analysis on racial/ethnic differences in pain threshold between African Americans and non-Hispanic whites. *Studies with older patients with knee osteoarthritis, **studies with patients with chronic pain, *** studies with older adults.

racial/ethnic differences in CPM in healthy young adults.[26] Recently, increased CPM in healthy AA youth compared with NHW youth was reported.[50] A study of CPM among old adults with knee OA reported a significant increase in pain ratings in AAs—pain facilitation, whereas no significant changes were observed in NHWs.[12] No significant effect of CPM was reported in one study of middle-aged and older AA and NHW adults.[58] Palit et al.[53] examined emotional modulation of pain, and found pain inhibition by erotic picture viewing in both healthy young Native Americans and NHWs. Pain facilitation by mutilation was found in NHWs, but not in Native Americans. Overall, the findings of racial/ethnic differences in CPM are inconsistent, and it is difficult to draw conclusions regarding the existence of racial/ethnic differences in CPM.

### *3.8. Quantitative synthesis/meta-analysis*

Thirty-three studies that examined differences in experimental pain sensitivity were included in the meta-analysis (**Fig. 1**). The pooled

SMDs of tolerance, threshold, and pain ratings were estimated by pain modality. Some studies used in the qualitative analysis were omitted from the quantitative analysis as follows: 8 studies were excluded because of insufficient quantitative information in the original article.[9,13,37,49,50,53,61,62] One study was excluded because it included NHW, Asian, and Hispanic in one group.[45] Two studies were excluded because their specialized study characteristics (children sample, chemical pain stimulation) made it difficult to conduct subgroup analyses.[42,67] The Egger test revealed no significant publication bias in the threshold (Egger bias = 0.723, 95% CI = −1.406 to 2.852, $P = 0.499$), tolerance (Egger bias = −2.25, 95% CI = −4.818 to 0.327, $P = 0.085$), and pain rating (Egger bias = 2.630, 95% CI = −0.114 to 5.375, $P = 0.060$) analyses.

In general, the SMDs for threshold were small and not significant (**Fig. 2**, overall SMD = −0.06, 95% CI = −0.19 to 0.07). The overall effect size of pain tolerance between AAs and NHWs was statistically significant (SMD = −0.64, 95% CI = −0.80 to −0.48) with high heterogeneity ($I^2 = 86.5\%$). The meta-analytic SMDs for tolerance of each modality (cold pain, heat pain, and ischemic pain) were large and statistically significant individually, whereas SMDs for electrical and pressure pain were not significant (**Fig. 3**). For suprathreshold pain ratings, the individual modality SMDs were medium to large and statistically significant, except in the case of electrical pain (**Fig. 4**, overall SMD = 0.46, 95% CI = 0.30–0.61). In addition, we calculated a pooled SMD for pain unpleasantness, and the results revealed a significant medium effect size for pain unpleasantness as shown in **Figure 5** (SMD = 0.37, 95% CI = 0.19−0.54).

### 3.9. Sensitivity and subgroup analyses

The sensitivity analyses results (**Table 10**, top) were comparable to the primary analyses results, with both analyses indicating

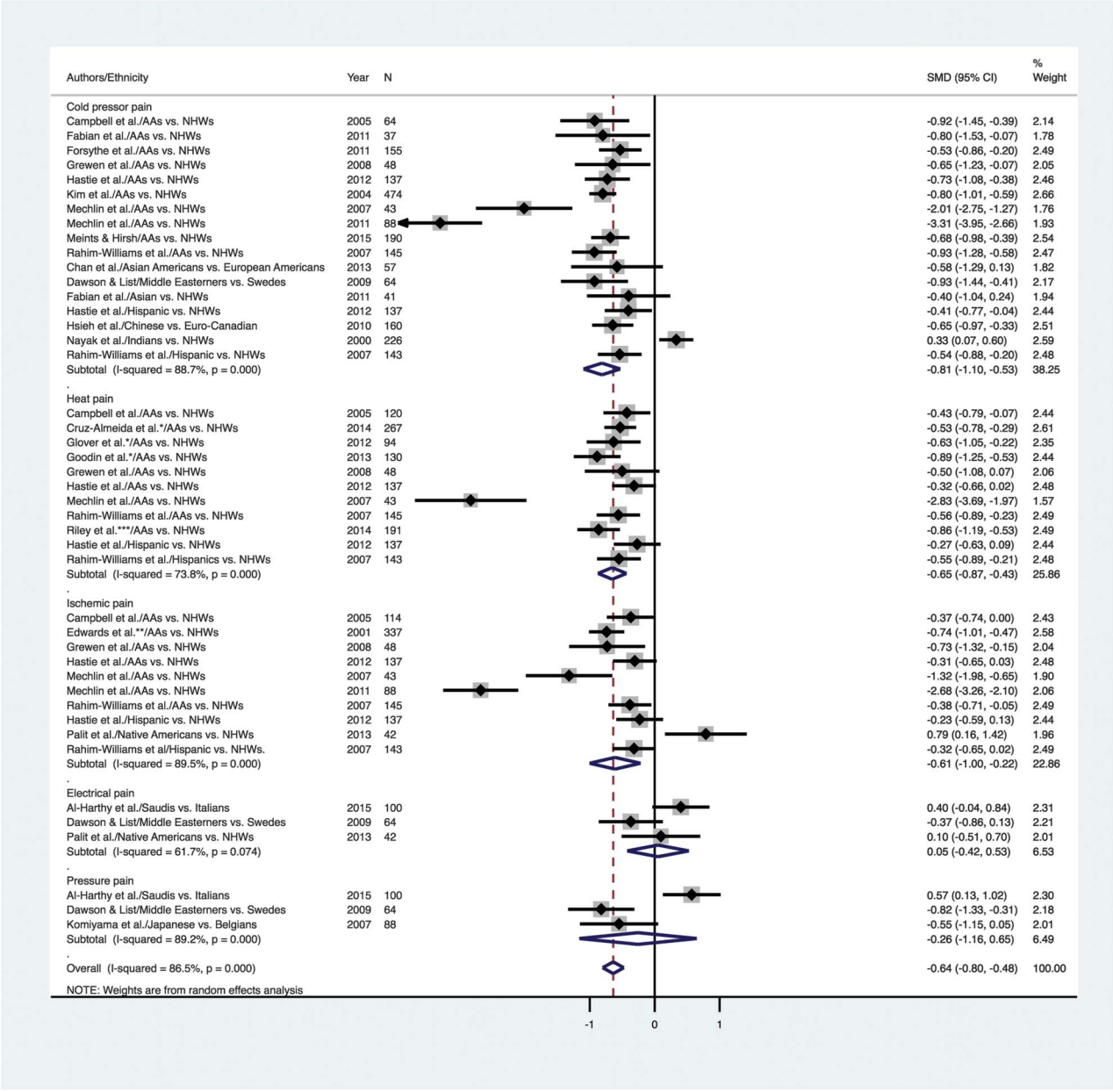


**Figure 3.** Meta-analysis on racial/ethnic differences in pain tolerance between African Americans and non-Hispanic whites. *Studies with older patients with knee osteoarthritis, **studies with patients with chronic pain, *** studies with older adults.

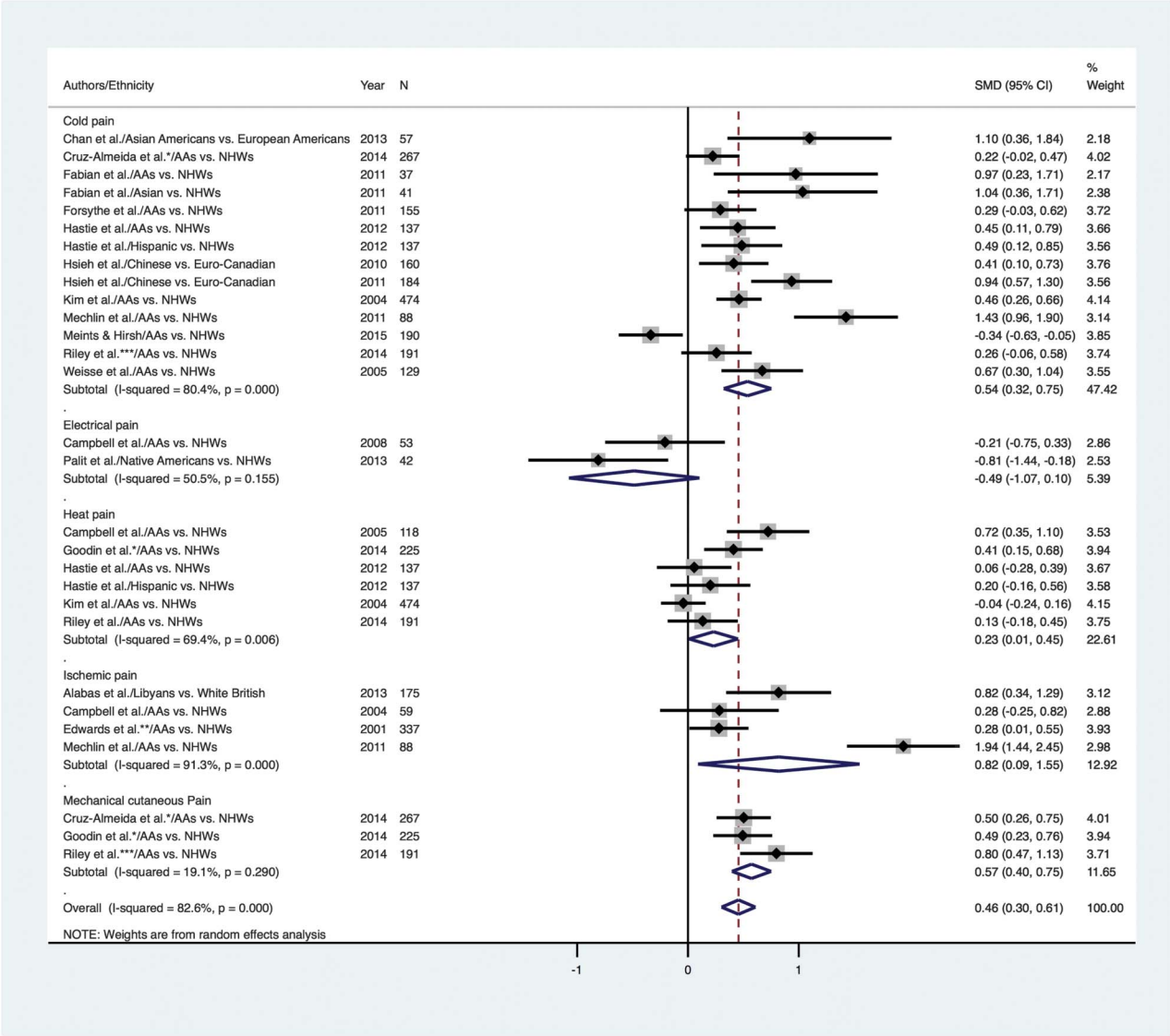


**Figure 4.** Meta-analysis on racial/ethnic differences in pain intensity ratings between African Americans and non-Hispanic whites. *Studies with older patients with knee osteoarthritis, **studies with patients with chronic pain, *** studies with older adults.

significant effect sizes for tolerance and pain ratings, but a nonsignificant effect size for threshold. Regarding the subgroup analyses, the SMDs did not differ statistically by the percentage of women, sample characteristics (young healthy adults vs patients with chronic pain), or pain modality. Accordingly, subgroup effects based on sex, sample characteristics, and pain modalities did not explain the high heterogeneity found in the primary analysis. However, the SMDs of tolerance and pain ratings were significantly larger for studies with a small sample size ($n < 100$) compared with studies with a larger sample size ($n \geq 100$). The SMD of tolerance in AAs was significantly larger than in Asians and other ethnic groups.

## 4. Discussion

This study provides an update on racial/ethnic differences in experimental pain sensitivity by incorporating the most recent literature. Reviewed studies examined racial/ethnic differences in experimental pain sensitivity using various types of stimulus modalities with multiple pain sensitivity measures. Overall, we found that racial/ethnic minorities had higher pain sensitivity compared with NHWs, specifically showing lower pain tolerance, higher pain intensity and unpleasantness ratings, and greater TS of pain, regardless of stimulus modality. This analysis is generally consistent with that previously been reported regarding racial/ethnic differences in pain sensitivity.[56] This study adds to the literature by providing analyses that allow for a quantitative comparison of racial/ethnic differences across various stimulus modalities and pain measures.

The meta-analysis of studies comparing AAs and NHWs found large estimated SMDs for pain tolerance, moderate to large SMDs for suprathreshold pain intensity ratings and unpleasantness, but no significant pooled SMDs in pain threshold. A previous review on racial/ethnic differences in experimental pain sensitivity also indicated that the effect sizes were consistently moderate to large for pain tolerance but small to moderate for pain threshold, whereas limited data were available for suprathreshold pain ratings.[56] The current review found medium to large effect sizes not only for tolerance but for both suprathreshold intensity and unpleasantness ratings. These results

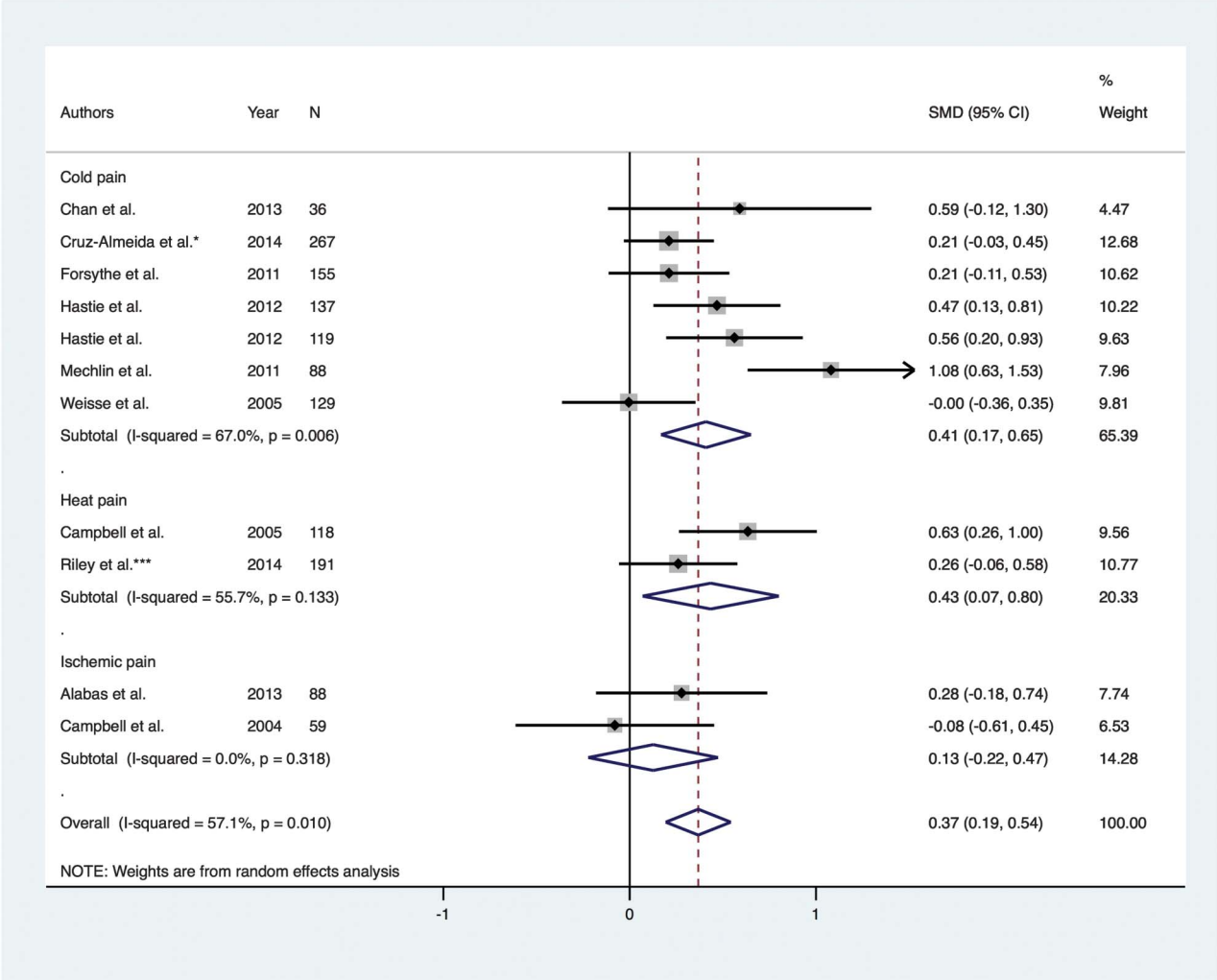


**Figure 5.** Meta-analysis on racial/ethnic differences in pain unpleasantness ratings between African Americans and non-Hispanic whites. *Studies with older patients with knee osteoarthritis, **studies with patients with chronic pain, *** studies with older adults.

suggest that racial/ethnic differences in experimental pain sensitivity are more pronounced in suprathreshold pain experiences than in thresholds. This may be important because suprathreshold pain measures have been reported to be among the most relevant experimental pain tasks to clinical pain.[7,15]

Greater experimental pain sensitivity among females compared with males has been frequently reported.[28] Enhanced experimental pain sensitivity in patients with chronic pain has also been reported.[40,55] Subgroup analyses in the current report revealed that racial/ethnic differences did not vary significantly according to sex or sample characteristics (healthy adults vs patients with chronic pain). In regard to experimental pain modality, one study documented that racial/ethnic differences in cold pain responses were more prominent than in heat pain.[36] Al-Harthy et al.[3] also reported that mechanical pain responses differed more than did electrical pain responses among different race/ethnic groups. However, the results of this study suggest that racial/ethnic differences in experimental pain sensitivity are more frequently found across multiple pain modalities than within a single modality.

In our analyses, there was a variance in racial/ethnic differences by ethnicity, specifically for tolerance. For example, the SMD for comparing AAs and NHWs was significantly higher compared with those of Asians or other ethnic groups vs NHWs. It is difficult to draw a conclusion because the majority of the studies found in this review compared AAs and NHWs, and there were relatively few studies of other ethnic groups, including Asians and Hispanics. More studies are needed in these racial/ethnic groups to test the variance in subgroup racial/ethnic differences in experimental pain sensitivity.

Sample size was another significant factor in subgroup differences of the pooled SMDs of tolerance and pain intensity rating, indicating that small studies reported large effects. This result could be partially explained by publication bias. Publication bias is more frequent in small-sample studies than in large sample studies because a small study that does not demonstrate significant effects is unlikely to be published.[63]

We included racial/ethnic differences in dynamic responses to experimental pain stimulation, which were measured by TS and CPM. In addition to the racial/ethnic differences in basal pain sensitivity, our analysis revealed that AAs exhibited higher TS among patients with OA,[12] young healthy adults,[43] and elderly,[58] suggesting an upregulated central nociceptive processing system among AAs than among NHWs. Deficient pain inhibition has been reported as a significant predictor of the severity of clinical pain, which supports that pain modulation capacity has an important role in chronic pain.[12] Although reduced pain-inhibitory function, measured by CPM, has been suggested as a potential

**Table 10**

**Subgroup and sensitivity analyses of the selected studies on racial/ethnic differences in experimental pain sensitivity.**

| | Tolerance | | Threshold | | Pain intensity rating | |
|---|---|---|---|---|---|---|
| | SMD (95% CI) | Sig,* *P* | SMD (95% CI) | Sig* | SMD (95% CI) | Sig* |
| Primary analysis | −0.64 (−0.80 to −0.48) | | −0.06 (−0.19 to 0.07) | | 0.46 (0.30 to 0.61) | |
| Sensitivity analysis | | | | | | |
| Excluding studies of no definition of race/ethnicity | −0.45 (−0.59 to −0.31) | | −0.05 (−0.18 to 0.08) | | 0.38 (0.25 to 0.51) | |
| Subgroup analysis | | | | | | |
| % of women | | 0.446 | | 0.751 | | 0.594 |
| Ethnicity | | | | | | |
| AAs vs NHWs | −0.90 (−1.10 to −0.70) | Ref. group | 0.08 (−0.24 to 0.08) | Ref. group | 0.44 (0.26 to 0.61) | Ref. group |
| Asians vs NHWs | −0.34 (−0.85 to 0.17) | 0.010 | −0.25 (−0.62 to 0.11) | 0.786 | 0.80 (0.44 to 1.16) | 0.422 |
| Hispanics vs NHWs | −0.39 (−0.53 to −0.26) | 0.323 | −0.06 (−0.18 to 0.07) | 0.776 | 0.34 (0.06 to 0.62) | 0.792 |
| Others vs NHWs | −0.04 (−0.54 to 0.46) | 0.006 | 0.31 (−0.34 to 0.97) | 0.077 | 0.02 (−1.58 to 1.61) | 0.306 |
| Sample size | | | | | | |
| <100 | −0.99 (−1.41 to −0.57) | 0.001 | −0.08 (−0.37 to 0.21) | 0.947 | 0.72 (0.06 to 1.37) | 0.004 |
| ≥100 | −0.44 (−0.58 to −0.30) | | −0.06 (−0.19 to 0.07) | | 0.38 (0.25 to 0.50) | |
| Sample characteristics | | | | | | |
| Young healthy adults | −0.64 (−0.82 to −0.45) | 0.862 | −0.03 (−0.18 to 0.11) | 0.417 | 0.48 (0.28 to 0.68) | 0.478 |
| Patients with chronic pain | −0.67 (−0.82 to −0.52) | | −0.33 (−0.54 to −0.13) | | 0.38 (0.27 to 0.49) | |
| Pain modality | | | | | | |
| Cold pain | −0.81 (−1.10 to −0.53) | Ref. group | −0.00 (−0.22 to 0.22) | Ref. group | 0.54 (0.32 to 0.75) | Ref. group |
| Electrical pain | 0.05 (−0.42 to 0.53) | 0.954 | −0.31 (−0.93 to 0.30) | 0.085 | −0.49 (−1.07 to 0.10) | 0.030 |
| Heat pain | −0.65 (−0.87 to −0.43) | 0.449 | −0.25 (−0.51 to 0.01) | 0.406 | 0.23 (0.01 to 0.45) | 0.703 |
| Ischemic pain | −0.61 (−1.00 to −0.22) | 0.230 | 0.33 (−0.07 to 0.73) | 0.284 | 0.82 (0.09 to 1.55) | 0.131 |
| Pressure pain | −0.26 (−1.16 to 0.65) | 0.669 | −0.03 (−0.28 to 0.22) | 0.815 | | |
| Mechanical cutaneous pain | | | −0.64 (−1.00 to −0.29) | 0.216 | 0.46 (0.30 to 0.61) | 0.195 |

* Random-effects meta-regression models (with 95% confidence interval [CIs]) were conducted to explore the subgroup differences (DerSimonian and Laird).
AA, African American; NHW, non-Hispanic white; SMD, standardized mean difference.

contributing factor to the racial/ethnic differences in clinical pain response,[9] the evidence found in current review in this regard is sparse and inconclusive. Future research is needed to address how these pain modulatory systems differ across racial/ethnic groups and affect clinical pain response.

Several limitations in this review, and its component studies, should be noted. First, the results of the present analyses are likely influenced by several methodological limitations of the reviewed studies. Most of the studies recruited a "convenience sample" rather than a systematic representation of a population. For example, several studies recruited participants from a university campus or from clinics. Heterogeneity of Asian populations, including the countries of the participants, was relatively high. For example, some studies included people with origins from many different Asian countries with no distinction, whereas others recruited only Asians with specific backgrounds. Similar inconsistent recruitment is also a limitation for the studies examining differences between Hispanic and non-Hispanic groups. Furthermore, experimenter characteristics and language proficiency of both participants and experimenter could influence the results of these studies. Finally, although most of the studies included age and sex as confounding factors in their study, socioeconomic factors (eg, education and income) were not considered in most of the studies.

Second, heterogeneity across the studies was considerably high, and the samples were diverse in age and context. As noted above, the characteristics of the "Asian" and "Hispanic" cohorts could vary greatly across studies. Furthermore, some studies compared ethnic groups with Asians living in their home country, whereas most recruited those living locally, usually either in the United States or Europe. For studies conducted in the United States or Europe, there was typically no distinction made between first-generation or later-generation AAs, Asians, or Hispanics, which could have a large impact upon study results because of cultural factors.[11,51]

## 5. Conclusions

We have systematically reviewed the scientific literature addressing racial and ethnic differences in experimental pain sensitivity. Our review included studies using various types of stimulus modalities and pain measures. Despite considerable heterogeneity across studies, racial/ethnic minorities generally showed higher pain sensitivity compared with NHWs. Racial/ethnic minorities commonly had lower pain tolerance and higher pain ratings across all pain modalities; however, differences in pain threshold were most often statistically not significant. Given the reported relationship between experimental pain sensitivity and clinical pain severity, health care providers who serve multiple racial/ethnic groups should consider these differences when they implement pain management programs. Further research is required to identify the biopsychosocial factors underlying racial/ethnic differences in pain sensitivity, specifically for the less-studied Asians and Hispanics in the United States. Researchers should consider the methodological challenges found in the studies when they plan studies that include considerations of racial/ethnic differences in pain sensitivity.

## Conflict of interest statement

The authors declare that they have no conflicts of interest.

## Appendix A. Supplemental Digital Content

Supplemental Digital Content associated with this article can be found online at http://links.lww.com/PAIN/A351.

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## References

[1] Agency for Healthcare Research and Quality. Methods guide for effectiveness and comparative effectiveness reviews, 2009. Available at: http://effectivehealthcare.ahrq.gov/ehc/products/60/318/CERMethods-Guide-140109.pdf. Accessed August 19, 2016.
[2] Alabas OA, Tashani OA, Johnson MI. Effects of ethnicity and gender role expectations of pain on experimental pain: a cross-cultural study. Eur J Pain 2013;17:776–86.
[3] Al-Harthy M, Ohrbach R, Michelotti A, List T. The effect of culture on pain sensitivity. J Oral Rehabil 2016;43:81–8.
[4] Anderson KO, Green CR, Payne R. Critical review: racial and ethnic disparities in pain: causes and consequences of Unequal care. J Pain 2009;10:1187–204.
[5] Bolen J, Schieb L, Hootman JM, Helmick CG, Theis K, Murphy LB. Differences in the prevalence and impact of arthritis among racial/ethnic groups in the United States, National Health Interview Survey, 2002, 2003, and 2006. Prev Chronic Dis 2010;7:1–5.
[6] Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. Introduction to Meta-Analysis. Hoboken, NJ; John Wiley & Sons, Ltd, 2009.
[7] Campbell CM, Edwards RR, Fillingim RB. Ethnic differences in responses to multiple experimental pain stimuli. PAIN 2005;113:20–6.
[8] Campbell CM, France CR, Robinson ME, Logan HL, Geffken GR, Fillingim RB. Ethnic differences in the nociceptive flexion reflex (NFR). PAIN 2008;134:91–6.
[9] Campbell CM, France CR, Robinson ME, Logan HL, Geffken GR, Fillingim RB. Ethnic differences in diffuse noxious inhibitory controls. J Pain 2008;9:759–66.
[10] Campbell TS, Hughes JW, Girdler SS, Maixner W, Sherwood A. Relationship of ethnicity, gender, and ambulatory blood pressure to pain sensitivity: effects of individualized pain rating scales. J Pain 2004;5:183–91.
[11] Chan MYP, Hamamura T, Janschewitz K. Ethnic differences in physical pain sensitivity: role of acculturation. PAIN 2013;154:119–23.
[12] Cruz-Almeida Y, Sibille KT, Goodin BR, Petrov ME, Bartley EJ, Riley JL, King CD, Glover TL, Sotolongo A, Herbert MS, Schmidt JK, Fessler BJ, Staud R, Redden D, Bradley LA, Fillingim RB. Racial and ethnic differences in older adults with knee osteoarthritis. Arthritis Rheumatol 2014;66:1800–10.
[13] Das Gupta E, Zailinawati AH, Lim AW, Chan JB, Yap SH, Hla YY, Kamil MA, Teng CL. Are Indians and females less tolerant to pain? An observational study using a laboratory pain model. Med J Malays 2009;64:111–13.
[14] Dawson A, List T. Comparison of pain thresholds and pain tolerance levels between Middle Easterners and Swedes and between genders. J Oral Rehabil 2009;36:271–8.
[15] Edwards RR, Doleys DM, Fillingim RB, Lowery D. Ethnic differences in pain tolerance: clinical implications in a chronic pain population. Psychosom Med 2001;63:316–23.
[16] Edwards RR, Fillingim RB. Ethnic differences in thermal pain responses. Psychosomatic Med 1999;61:346–54.
[17] Fabian LA, McGuire L, Goodin BR, Edwards RR. Ethnicity, catastrophizing, and qualities of the pain experience. Pain Med 2011;12:314–21.
[18] Fillingim RB, King CD, Ribeiro-Dasilva M, Rahim-Williams B, Riley IJ. Critical review: sex, gender, and pain: a review of recent clinical and experimental findings. J Pain 2009;10:447–85.
[19] Forsythe LP, Thorn B, Day M, Shelby G. Race and sex differences in primary appraisals, catastrophizing, and experimental pain outcomes. J Pain 2011;12:563–72.
[20] Gagnon CM, Matsuura JT, Smith CC, Stanos SP. Ethnicity and interdisciplinary pain treatment. Pain Pract 2014;14:532–40.
[21] Gatchel RJ, Peng YB, Peters ML, Fuchs PN, Turk DC. The biopsychosocial approach to chronic pain: scientific advances and future directions. Psychol Bull 2007;133:581–624.
[22] Gazerani P, Arendt-Nielsen L. The impact of ethnic differences in response to capsaicin-induced trigeminal sensitization. PAIN 2005;117:223–9.
[23] Glover TL, Goodin BR, Horgas AL, Kindler LL, King CD, Sibille KT, Peloguin CA, Riley JL, Staud R, Bradley LA, Fillingim RB. Vitamin D, race, and experimental pain sensitivity in older adults with knee osteoarthritis. Arthritis Rheum 2012;64:3926–35.
[24] Goodin BR, Bulls HW, Herbert MS, Schmidt J, King CD, Glover TL, Sotolongo A, Sibille KT, Cruz-Almeida Y, Staud R, Fessler BJ, Redden DT, Bradley LA, Fillingim RB. Temporal summation of pain as a prospective predictor of clinical pain severity in adults aged 45 years and older with knee osteoarthritis: ethnic differences. Psychosom Med 2014;76:302–10.
[25] Goodin BR, Pham ZT, Glover TL, Sotolongo A, King CD, Sibille KT, Heerbert MS, Cruz-Almeida Y, Sanden SH, Staud R, Redden DT, Bradley LA, Fillingim RB. Perceived racial discrimination, but not mistrust of medical researchers, predicts the heat pain tolerance of African Americans with symptomatic knee osteoarthritis. Health Psychol 2013;32:1117–26.
[26] Goodin BR, Kronfli T, King CD, Glover TL, Sibille K, Fillingim RB. Testing the relation between dispositional optimism and conditioned pain modulation: does ethnicity matter? J Behav Med 2013;36:165–74.
[27] Green CR, Anderson KO, Baker TA, Campbell LC, Decker S, Fillingim RB, Kalauokalani DA, Lasch KE, Myers C, Tait RC, Todd KH, Vallerand AH. The unequal burden of pain: confronting racial and ethnic disparities in pain. Pain Med 2003;4:277–94.
[28] Greenspan JD, Traub RJ. Gender differences in pain and its relief. In: McMahon S, Koltzenburg M, Tracey I, Turk DC, editors. Wall and Melzack's textbook of pain, 6th ed. Amsterdam: Elsevier, 2013. p. 221–31.
[29] Grewen KM, Light KC, Mechlin B, Girdler SS. Ethnicity is associated with alterations in oxytocin relationships to pain sensitivity in women. Ethn Health 2008;13:219–41.
[30] Hastie BA, Riley JL, Kaplan L, Herrera DG, Campbell CM, Virtusio K, Mogil JS, Wallace MR, Fillingim RB. Ethnicity interacts with the OPRM1 gene in experimental pain sensitivity. PAIN 2012;153:1610–19.
[31] Hassenbusch SJ, Paice JA, Patt RB, Bedder MD, Bell GK. Clinical realities and economic considerations: economics of intrathecal therapy. J Pain Symptom Manage 1997;14:S36–48.
[32] Hooten WM, Knight-Brown M, Townsend CO, Laures HJ. Rehabilitation section: clinical outcomes of multidisciplinary pain rehabilitation among African American compared with Caucasian patients with chronic pain. Pain Med 2012;13:1499–508.
[33] Hsieh AY, Tripp DA, Ji L. The influence of ethnic concordance and discordance on verbal reports and nonverbal behaviours of pain. PAIN 2011;152:2016–22.
[34] Hsieh AY, Tripp DA, Ji L, Sullivan MJL. Comparisons of catastrophizing, pain attitudes, and cold-pressor pain experience between Chinese and European Canadian young adults. J Pain 2010;11:1187–94.
[35] Institute of Medicine. Relieving pain in America: A blueprint for Transforming prevention, care, education, and research. Washington, DC: The National Academies Press, 2011.
[36] Kim H, Neubert JK, Rowan JS, Brahim JS, Iadarola MJ, Dionne RA. Comparison of experimental and acute clinical pain responses in humans as pain phenotypes. J Pain 2004;5:377–84.
[37] Klatzkin RR, Mechlin B, Bunevicius R, Girdler SS. Race and histories of mood disorders modulate experimental pain tolerance in women. J Pain 2007;8:861–8.
[38] Komiyama O, Kawara M, De Laat AEthnic differences regarding tactile, pain thresholds in the trigeminal region. J Pain 2007;8:363–9.
[39] Komiyama O, Wang K, Svensson P, Arendt-Nielsen L, Kawara M, De Laat A. Ethnic differences regarding sensory, pain, and reflex responses in the trigeminal region. Clin Neurophysiol 2009;120:384–9.
[40] Laarhoven AIM, Kraaimaat FW, Wilder-Smith O, Riel PLCM, Kerkhof PCM, Evers AWM. Sensitivity to itch and pain in patients with psoriasis and rheumatoid arthritis. Exp Dermatol 2013;22:530–4.
[41] Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol 2009;62:e1–34.
[42] Lu Q, Zeltzer L, Tsao J. Multiethnic differences in responses to laboratory pain stimuli among children. Health Psychol 2013;32:905–14.
[43] Mechlin B, Heymen S, Edwards CL, Girdler SS. Ethnic differences in cardiovascular-somatosensory interactions and in the central processing of noxious stimuli. Psychophysiology 2011;48:762–73.
[44] Mechlin B, Morrow AL, Maixner W, Girdler SS. The relationship of allopregnanolone immunoreactivity and HPA-axis measures to experimental pain sensitivity: evidence for ethnic differences. PAIN 2007;131:142–52.
[45] Mechlin MB, Maixner W, Light KC, Fisher JM, Girdler SS. African Americans show alterations in endogenous pain regulatory mechanisms and reduced pain tolerance to experimental pain procedures. Psychosom Med 2005;67:948–56.
[46] Meghani SH. Corporatization of pain medicine: implications for widening pain care disparities. Pain Med 2011;12:634–44.

[47] Meints SM, Hirsh AT. In vivo praying and catastrophizing mediate the race differences in experimental pain sensitivity. J Pain 2015;16:491–7.
[48] Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Int J Surg 2010;8:336–41.
[49] Morris MC, Walker L, Bruehl S, Hellman N, Sherman AL, Rao U. Race effects on temporal summation to heat pain in youth. PAIN 2015;156: 917–22.
[50] Morris MC, Walker L, Bruehl S, Hellman N, Sherman AL, Rao U. Race effects on conditioned pain modulation. J Pain 2015;16:873–80.
[51] Nayak S, Shiflett SC, Eshun S, Levine FM. Culture and gender effects in pain beliefs and the prediction of pain tolerance. Cross Cultural Res 2000; 34:135–51.
[52] Palit S, Kerr KL, Kuhn BL, Terry EL, DelVentura JL, Bartley EJ, Shadlow JO, Rhudy JL. Exploring pain processing differences in native Americans. Health Psychol 2013;32:1127–36.
[53] Palit S, Kerr KL, Kuhn BL, DelVentura JL, Terry EL, Bartley EJ, Shadlow JO, Rhudy JL. Examining emotional modulation of pain and spinal nociception in Native Americans: a preliminary investigation. Int J Psychophysiol 2013;90: 272–81.
[54] Parmelee PA, Harralson TL, McPherron JA, DeCoster J, Schumacher HR. Pain, disability, and depression in osteoarthritis: effects of race and sex. J Aging Health 2012;24:168–87.
[55] Puta C, Schulz B, Schoeler S, Magerl W, Gabriel B, Gabriel HW, Miltner WHR, Weiss T. Enhanced sensitivity to punctate painful stimuli in female patients with chronic low back pain. BMC Neurol 2012;12:98.
[56] Rahim-Williams B, Riley JL, Williams AKK, Fillingim RB. A quantitative review of ethnic group differences in experimental pain response: do biology, psychology, and culture matter? Pain Med 2012;13:522–40.
[57] Rahim-Williams F, Riley JLI II, Herrera D, Campbell CM, Hastie BA, Fillingim RB. Ethnic identity predicts experimental pain sensitivity in African Americans and Hispanics. PAIN 2007;129:177–84.
[58] Riley JL III, Cruz-Almeida Y, Glover TL, King CD, Goodin BR, Sibille KT, Bartley EJ, Herbert MS, Sotolongo A, Fessler BJ, Redden DT, Staud R, Bradley LA, Fillingim RB. Age and race effects on pain sensitivity and modulation among middle-aged and older adults. J Pain 2014;15:272–82.
[59] Riley IJ, Wade JB, Myers CD, Sheffield D, Papas RK, Price DD. Racial/ethnic differences in the experience of chronic pain. PAIN 2002;100: 291–8.
[60] Riskowski JL. Psychology, psychiatry and brain neuroscience section: associations of socioeconomic position and pain prevalence in the United States: findings from the national health and nutrition examination survey. Pain Med 2014;15:1508–21.
[61] Rowell LN, Mechlin B, Ji E, Addamo M, Girdler SS. Asians differ from non-Hispanic Whites in experimental pain sensitivity. Eur J Pain 2011;15: 764–71.
[62] Sheffield D, Biles PL, Orom H, Maixner W, Sheps DS. Race and sex differences in cutaneous pain perception. Psychosom Med 2000;62: 517–23.
[63] Slavin R, Smith D. The relationship between sample sizes and effect sizes in systematic reviews in education. Educ Eval Policy Anal 2009;31: 500–6.
[64] Sterne J. Meta-analysis in Stata: an updated collection from Stata Journal. College Station: Stata Press, 2009.
[65] Tan G, Jensen MP, Thornby J, Anderson KO. Ethnicity, control appraisal, coping, and adjustment to chronic pain among black and white Americans. Pain Med 2005;6:18–28.
[66] US Census Bureau. The Asian population, 2010. Available at: http://www.census.gov/prod/cen2010/briefs/c2010br-11.pdf. Accessed August 19, 2016.
[67] Wang H, Papoiu ADP, Coghill RC, Patel T, Wang N, Yosipovitch G. Ethnic differences in pain, itch and thermal detection in response to topical capsaicin: African Americans display a notably limited hyperalgesia and neurogenic inflammation. Br J Dermatol 2010;162:1023–9.
[68] Watson PJ, Latif RK, Rowbotham DJ. Ethnic differences in thermal pain responses: a comparison of South Asian and White British healthy males. PAIN 2005;118:194–200.
[69] Weisse CS, Foster KK, Fisher EA. The influence of experimenter gender and race on pain reporting: does racial or gender concordance matter? Pain Med 2005;6:80–7.
[70] Yang G, Luo Y, Baad-Hansen L, Wang K, Arendt-Nielsen L, Zie QF, Svensson P. Ethnic differences in oro-facial somatosensory profiles-quantitative sensory testing in Chinese and Danes. J Oral Rehabil 2013; 40:844–53.