Predictors of Cold and Pressure Pain Tolerance in Healthy South African Adults

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Abstract

Background. Studies on relationships between sex, ethnicity, and pain have largely emanated from the United States and Europe. We compared cold (CPT) and pressure pain tolerance (PPT) in male and female South Africans of African and European ancestry and assessed whether psychosocial factors (including pain beliefs) predicted differences in pain tolerance.

Methods. We recruited 106 (62 female) students of African ancestry and 106 (55 female) of European ancestry and subjected them to a cold-pressor test and pressure algometry. Socioeconomic status (SES), pain catastrophizing, depression, anxiety, and pain beliefs were assessed as predictors of pain tolerance.

Results. CPT was lower in students of African compared with European ancestry (for both sexes), and PPT was lower in female than male students (for both ethnicities). Females were very accepting of men expressing pain and males less so. Males of African ancestry were least accepting but still tolerant. Multivariate analysis identified African ancestry, and particularly being a female of African ancestry, as strong predictors of lower CPT. Anxiety was a weak predictor of CPT. Sex was the only strong predictor of PPT on multivariate analysis (PPT females < males), and catastrophizing was a weak predictor. Female sex and African ancestry were strong predictors of acceptance of expression of pain in males. SES was a weak predictor of the Appropriate Pain Behavior Questionnaire-Malescore.

Conclusions. Despite different cultural and social backgrounds from US and European cohorts, we saw similar patterns of sex and ethnic differences in CPT and PPT in an African cohort. Traditional psychosocial predictors of pain sensitivity predicted variation in the outcome variables but were not strong predictors.

Key Words. Cold; Pressure; Pain; Tolerance; Experimental; African

Introduction

Sex differences in clinical and experimental pain conditions have been well studied [1]. Clinically, pain is more prevalent in females who are also likely to experience pain more severely [2,3], and females also have higher pain sensitivity under some experimental conditions such as lower tolerance to cold pain and pressure pain [1]. A recent systematic review suggested that there is little evidence for the effect of biological and physiological factors on these sex differences, but that psychosocial factors may play a role [4].

Differences in pain sensitivity clinically and experimentally have also been reported between ethnicities, but there are far fewer studies published compared with sex differences in pain sensitivity. In general, compared with
people of European descent, African Americans tend to report greater pain sensitivity and disability, for example in African Americans with chronic pain [5,6]. Additionally, African Americans have displayed lower tolerance, higher pain intensity, and unpleasantness to several experimental pain stimuli [7,8]. Psychosocial factors such as socioeconomic status, hypervigilance, and acculturation may contribute to differences in pain sensitivity between ethnicities [7,9,10].

Importantly, ethnicity and sex interact. For example, differences in pain catastrophizing between Americans of African and European ancestry mediated the sex differences seen in cold pain tolerance [8]. As psychosocial influences on pain perception and behavior vary across cultures and countries, the effect these influences have on pain experience and expression cannot necessarily be generalized. So while sex differences may have been well studied in US and European populations, these differences require confirmation in other cohorts including from Africa. Indeed, there is a dearth of data on pain sensitivity, psychosocial modulators of pain sensitivity, and pain beliefs in populations of African ancestry from Africa (we are unaware of any published studies on populations from sub-Saharan Africa).

While several psychosocial factors and their impact on pain both clinically and experimentally have been well studied, beliefs regarding the appropriateness of reporting and expression of pain have not. What studies there are suggest that beliefs about expression of pain may influence pain sensitivity between sexes and ethnicities. For example, Israeli females believed that women had lower pain sensitivity than did men, but females from the United States, the United Kingdom, and Libya expressed the opposite belief [11–13]. And in a study comparing pain beliefs and pain tolerance in Indian and US university students, Indian students were less accepting about others expressing pain and had greater cold pain tolerance than their American counterparts [14]. The association between beliefs about expression of pain and pain tolerance has not been assessed for more than one pain stimulus before. Furthermore, neither pain beliefs nor their effect on pain tolerance has been assessed in an African population.

Having experimental pain data for an African population would provide a basis for greater understanding of geo-ethnic variation in pain sensitivity and beliefs. Therefore we investigated: 1) pain tolerance to thermal and mechanical stimuli, 2) beliefs about pain expression, and 3) psychosocial factors that may influence pain sensitivity in a South African cohort of African ancestry. To establish whether there are sex differences in the measured variables, we compared responses in males and females. Lastly, we compared the results to a cohort of males and females of European ancestry. Our null hypothesis was that there would be no difference in pain tolerance to either cold or pressure stimuli between the sexes or ethnicities.

Methods

Participants

The study was approved by the Human Research Ethics Committee (medical) of the University of the Witwatersrand (clearance certificate: M120648). We recruited healthy students of self-identified African and European ancestry from the student population at the University of the Witwatersrand, Johannesburg, between September 2012 and June 2013. All participants were at least in their second year of study at the university level and were not subordinate to the investigators. Students were informed of the study at the beginning of Physiology practical sessions and invited to participate. Students were not reimbursed, nor was there any other benefit to participating. The university is an English medium institution, and competence in English was assumed. Participants were excluded if they were pregnant, were taking medication for high blood pressure, were currently in pain, had a chronic pain condition, or had used analgesics within four hours of the interventions. We aimed to recruit at least 41 individuals into each ethnicity and sex group in order to detect an effect size of 0.57 for pain tolerance [15,16].

Measurements

Patients completed questionnaires to assess psychosocial factors (depression, anxiety, pain catastrophizing), socioeconomic status, and pain beliefs before taking part in cold-pressor and pressure pain tests. The experimenter recused herself while participants were completing the questionnaires.

Psychosocial Factors

The pain catastrophizing scale (PCS) was used to assess catastrophic thinking related to pain [17]. The PCS was administered before exposure to the experimental pain stimuli to determine trait catastrophizing, a person’s general tendency to catastrophize. Participants rated each of the 13 items on the questionnaire on a five-point Likert scale, ranging from 0 = “not at all” to 4 = “all the time.” The total score is 52, with a higher score indicating a greater tendency to catastrophize. PCS scores greater than 30 indicate a clinically significant level of catastrophizing [18]. The English version PCS has been validated in a South African cohort of fibromyalgia patients and had good convergent validity, test-retest reliability, and excellent internal consistency (α = 0.98) [19].

Anxiety and depression were assessed using the 25-item Hopkins Symptom Checklist (HSCL-25) [20]. Participants rated the extent to which they had experienced each item on a four-point Likert scale ranging from 1 = “not
at all” to 4 = “extremely.” Mean scores for the 10-item anxiety subscale and the 15-item depression subscale items were calculated (mean subscale scores > 1.75 indicate clinically relevant levels of anxiety or depression [21]). We have recently validated the HSCL-25 in a cohort of South Africans living with HIV and found that the depression and anxiety subscales had excellent internal consistency (α = 0.94 and 0.95, respectively) [22,23].

Socioeconomic Status

No validated, quantifiable measure of socioeconomic status (SES) exists for the South African context. Core measurement domains of socioeconomic status (SES) include education, income, and occupation [24] and previously used measures in South Africa have assessed ownership of certain assets [25]. Therefore we measured education, income, and occupation in a similar manner to a previous study of pain and SES in the United States [10] and also asked about ownership of culturally relevant assets. Because the cohort consisted of full-time students, we used parental/guardian education level, employment status, and ownership of material household items as proxies for participants’ socioeconomic status.

Pain Beliefs

The Appropriate Pain Behavior Questionnaire (APBQ) was used to assess pain beliefs [14]. The questionnaire is a 14-item questionnaire that measures beliefs about the appropriateness of expressing pain in the presence of others. Assessed pain behaviors included crying, grimacing, talking about the pain, or holding the painful site. There are two components to the APBQ: the APBQ-Male (APBQ-M), which assesses how appropriate individuals find men expressing pain to be, and the APBQ-Female (APBQ-F), which assesses how appropriate individuals find women expressing pain to be. The scale has been validated in student populations previously. Internal consistency was good for both the APBQ-M and APBQ-F in US students (α = 0.89 and 0.95, respectively) and acceptable for Indian students (α = 0.80 and 0.74, respectively) [14].

Eight items on the APBQ express a positive attitude toward pain expression, and six express a negative attitude toward expressing pain. Participants rated the extent to which they agreed with each of the 14 statements by scoring them on a seven-point Likert scale, ranging from 1 = “strongly disagree” to 7 = “strongly agree.” To facilitate interpretation of APBQ scores, we calculated the difference between the mean score of the eight statements that assess whether it is appropriate to express pain behaviors and the mean score of the six statements that assess whether it is inappropriate to express pain behaviors. The final score has a bounded range of -6 to +6, with negative values indicating a bias toward pain expression being considered inappropriate and positive values indicating a bias toward pain expression being considered appropriate. We interpreted a score close to 0 as indicating that an individual had a neutral view of pain expression. Results of the APBQ were assessed both as an outcome measure in the univariate analysis and also as a dependent variable in the multivariate analysis.

Experimental Pain Procedures

Following completion of the questionnaires, participants underwent a cold-pressor test to assess cold pain tolerance (CPT), and then a pressure pain test to assess pressure pain tolerance (PPT). The order of the interventions was kept constant.

The cold-pressor test involved participants submerging their dominant hand in the middle of a bath of approximately 5°C water. The temperature of the water was monitored with a mercury bulb thermometer. A consistent temperature was maintained by routinely stirring the water during the test and adding more ice when necessary. The procedure ended when participants could no longer tolerate the cold or they reached a 300-second cutoff (participants were not informed about the cutoff before the intervention). Time in seconds was recorded from when participants submerged their dominant hand until they reached tolerance or the cutoff time was reached. On completion of the task, participants immediately recorded the intensity of their pain at tolerance or the cutoff time on a 100 mm visual analog scale (VAS) anchored at “no pain” and “the worst pain imaginable.”

Once participants had indicated that they had regained sensation and had no residual pain in their dominant hand, PPT was assessed in their nondominant hand. Pressure was applied to the nail bed of the index finger using a pressure algometer and algometry accessory (10 mm² probe; Algometer, Somedic AB, Sweden). The test was completed once per participant and was terminated when participants were unable to tolerate the pressure or a cutoff pressure of 1500 kPa was reached. The intensity being applied, and the intensity of the pain experienced at tolerance or cutoff pressure was recorded immediately after the intervention.

Statistical Analysis

Continuous parametric data are presented as mean (standard deviation) and nonparametric data as median (interquartile range [IQR]). A Fisher’s exact test was used to analyze each of the SES components (education, employment, and household assets) and those reaching the time and pressure cutoffs in the cold and pressure tests. A Kruskal-Wallis test was used to compare psychosocial variables, pain beliefs, and pain tolerance and intensities for the cold and pain tests. If participants did not complete a questionnaire fully, their score was excluded. For all univariate analyses, significant findings in omnibus tests were followed by specific post hoc comparisons, such that comparisons were performed between ethnicity-matched sex groups (European ancestry males vs European ancestry females, and African ancestry...
Predictors of Pain Tolerance in Africans

Two hundred twelve students were recruited and gave informed consent. One hundred six participants identified themselves as being of European ancestry (55 female), and 106 participants identified themselves as being of African ancestry (61 female). Of the 106 African ancestry participants, 23% (24/106) were first-language isiXhosa speakers, 18% (19/106) Sotho speakers, 12% (13/106) isiXhosa speakers, and 8% (8/106) English speakers. The remainder spoke a variety of other African languages. Of the 106 European ancestry participants, the majority spoke English as their first language (81%, 86/106) and 12% (13/106) were first-language Afrikaans speakers. The four groups (African ancestry males, European ancestry males, African ancestry females, and European ancestry females) were similar with regards to age (mean of whole cohort = 20.5 years, SD = 2.0; Kruskal-Wallis between groups: $P = 0.42$) and years of education (median = 14, range = 13–21; Kruskal-Wallis between groups: $P = 0.26$). Following post hoc analysis, body mass index was greater in European ancestry males than European ancestry females (24.3 vs 22.8 kg/m$^2$; Kruskal-Wallis; $P = 0.001$) but was similar between the other paired comparisons (Kruskal-Wallis; $P > 0.0125$). As there was no reason to expect any differences in SES between the sexes, we only compared our measures between ethnicities. There were differences in each of the SES measures between students of African and European ancestry (Table 1). Students of African ancestry had lower ownership of assets such as being less likely to own a car, washing machine, or microwave oven. In addition, the parents of African ancestry students were less likely to be employed and had achieved a lower level of education.

Univariate Analysis

Table 2 shows pain tolerance and pain intensity data for cold-pressor and pressure pain tests across the...
ancestry and sex groups and the number of individuals in each group who reached the cutoff limit.

Cold-Pressor Test Results

Cold pain tolerance differed significantly between the groups, such that female participants had a lower cold pain tolerance than their ancestry-matched male counterparts (Kruskal Wallis test: $P < 0.0001$; post hoc Dunn’s tests: AAF < AAM and EAF < EAM). However, within each sex, there were no significant differences between the groups of African and European ancestry (Kruskal-Wallis tests: $P > 0.05$). Despite the sex differences in pressure pain tolerance, all groups reported similar pain intensities at tolerance (Kruskal-Wallis: $P = 0.46$). Very few individuals reached the pressure cutoff, and there were no differences between the groups in the number of people who reached the cutoff (chi-square, $P = 0.08$).

Pressure Test Results

For the mechanical stimulus, females had a significantly lower pressure pain tolerance than their ancestry-matched male counterparts (Kruskal-Wallis tests: $P < 0.0001$; post hoc Dunn’s tests: AAF < AAM and EAF < EAM). However, within each sex, there were no significant differences between the groups of African and European ancestry (Kruskal-Wallis tests: $P > 0.05$). Despite the sex differences in pressure pain tolerance, all groups reported similar pain intensities at tolerance (Kruskal-Wallis: $P = 0.46$). Very few individuals reached the pressure cutoff, and there were no differences between the groups in the number of people who reached the cutoff (chi-square, $P = 0.08$).

Pain Beliefs

Table 3 shows the results of the APBQ assessment on attitudes toward the expression of pain by males (APBQ-M) and females (APBQ-F). Scores from the APBQ-M showed that on average all groups (irrespective of sex or ancestry) were accepting of females expressing pain. Scores from the APBQ-M differed, however. The median APBQ-M score for males of African ancestry were significantly lower than those of the other groups. Their score still was positive, but close to zero. Neither APBQ-M nor APBQ-F scores correlated with either CPT or PPT in any of the sex or ancestry groups (Spearman’s correlations: $P > 0.05$).

Pain Catastrophizing, Anxiety, and Depression

Table 4 shows the results for psychological variables (pain catastrophizing, anxiety, and depression) in the four groups. Females of African ancestry had higher catastrophizing scores than males of African ancestry and females of European ancestry. There were no differences in catastrophizing scores between the male groups or between females and males of European ancestry. While on average none of the groups had clinically relevant levels of pain catastrophizing [18], 19% of females of African ancestry, compared with 4% of females of European ancestry, 9% of males of African ancestry, and 2% of males of European ancestry, had catastrophizing scores greater than 30, which are considered clinically significant [18].

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Indicators of socioeconomic status</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>African ancestry count (%)</td>
</tr>
<tr>
<td>Parent/guardian’s education level (sample size)*</td>
<td>104</td>
</tr>
<tr>
<td>None</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Primary school</td>
<td>7 (7)</td>
</tr>
<tr>
<td>High school</td>
<td>16 (15)</td>
</tr>
<tr>
<td>Tertiary level</td>
<td>81 (78)</td>
</tr>
<tr>
<td>Parent/guardian’s employment status (sample size)*</td>
<td>106</td>
</tr>
<tr>
<td>Income</td>
<td>92 (87)</td>
</tr>
<tr>
<td>No income</td>
<td>14 (13)</td>
</tr>
<tr>
<td>Household assets (sample size)*</td>
<td>105</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>102</td>
</tr>
<tr>
<td>Yes</td>
<td>92 (87)</td>
</tr>
<tr>
<td>No</td>
<td>14 (13)</td>
</tr>
<tr>
<td>Television</td>
<td>102</td>
</tr>
<tr>
<td>Yes</td>
<td>99 (97)</td>
</tr>
<tr>
<td>No</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Car</td>
<td>99</td>
</tr>
<tr>
<td>Yes</td>
<td>77 (78)</td>
</tr>
<tr>
<td>No</td>
<td>22 (22)</td>
</tr>
<tr>
<td>Washing machine</td>
<td>101</td>
</tr>
<tr>
<td>Yes</td>
<td>80 (79)</td>
</tr>
<tr>
<td>No</td>
<td>21 (21)</td>
</tr>
<tr>
<td>Microwave</td>
<td>102</td>
</tr>
<tr>
<td>Yes</td>
<td>92 (90)</td>
</tr>
<tr>
<td>No</td>
<td>10 (10)</td>
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</tbody>
</table>

*Incomplete data. Education data analyzed with a chi-square test for trend. All other data analyzed with a Fisher's exact test.
Female participants had higher scores for the anxiety and depression subscales of the HSCL-25 than their ethnicity-matched male counterparts. There were no differences between the sex-matched groups on the anxiety subscale, nor between the female groups on the depression subscale, but males of African ancestry had greater depression scores than the males of European ancestry. Forty-nine percent of females of African ancestry and 40% of females of European ancestry had HSCL-25 anxiety subscale scores greater than 1.75, which are deemed clinically significant [21], compared with 12% of males of African ancestry and 8% of males of European ancestry. Similarly, 54% of females of African ancestry and 34% of females of European ancestry had HSCL-25 depression subscale scores greater than 1.75, compared with 19% of males of African ancestry and 2% of males of European ancestry.

**Multivariate Analysis**

Multivariate regression tree and random forest analysis were used to identify predictors of pain sensitivity and pain beliefs. Variables were included in the model if they were found to be significant on univariate analysis (i.e., predictors of cold pain tolerance, pressure pain tolerance, APBQ-M).

Figure 1 shows the regression tree analyses for predictors of cold and pressure pain tolerance, as well as scores for the Appropriate Pain Behaviour Questionnaire-Male. For cold pain tolerance, regression tree analysis identified that being of African ancestry, and particularly being a female of African ancestry, predicted lower cold pain tolerance. The importance of these two factors was confirmed by random forest analysis. Additionally, anxiety was identified as a weak predictor of CPT (Supplementary Figure 1). Regression tree analysis identified female sex as the only significant predictor of PPT (Supplementary Figure 2). Regression tree analysis identified that sex and self-identified ancestry were important predictors of APBQ-M score, such that being female predicted greater APBQ-M scores and, among males, being of African ancestry predicted significantly lower APBQ-M scores than did being of European ancestry. Random forest analysis supported these findings and also identified ownership of assets and education as weak predictors of APBQ-M (Supplementary Figure 3).

**Discussion**

We assessed 1) pain tolerance to thermal and mechanical stimuli, 2) beliefs about pain expression, and 3) psychosocial factors that may influence pain sensitivity in a South African cohort of African ancestry. As sex and ethnicity both affect pain tolerance in

<table>
<thead>
<tr>
<th>Table 2 Pain tolerance, intensity, and numbers reaching cutoff data for cold and pressure pain tests</th>
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<tbody>
<tr>
<td><strong>Males</strong></td>
</tr>
<tr>
<td><strong>African ancestry</strong></td>
</tr>
<tr>
<td>(N = 44)</td>
</tr>
<tr>
<td>Median (IQR)</td>
</tr>
<tr>
<td>Cold pain tolerance, s</td>
</tr>
<tr>
<td>Cold pain intensity, VAS = 0 to 100</td>
</tr>
<tr>
<td>Pressure pain tolerance, kPa</td>
</tr>
<tr>
<td>Pressure pain intensity, VAS = 0 to 100</td>
</tr>
</tbody>
</table>

Differences in pain tolerance and intensity analyzed with a Kruskal-Wallis. Numbers reaching test cutoff analyzed with a Fisher’s exact test. Results presented in the text.
clinical and experimental conditions, we assessed sex differences in these variables and also compared the results to a cohort of males and females of European descent. This was the first assessment of factors affecting pain tolerance and intensity of experimental pain in a sub-Saharan African population and the first time more than one stimuli has been assessed in any African population. Our study was necessary because cultural and social factors are reportedly important in influencing pain tolerance [1,8,10]. These factors vary between populations, and the available data are primarily from the United States and Europe, with almost no African, and certainly no sub-Saharan African, data. We hypothesized that, in contrast to previous data, there would be no difference between students of African or European ancestry for tolerance to either cold or pressure stimuli, which was true for tolerance to the pressure test, but there was a difference between students of African and European ancestry for tolerance to the cold test. Males of African ancestry were the least accepting of males expressing pain, but pain beliefs did not explain differences in cold pain tolerance. Anxiety was identified as a weak predictor of cold pain tolerance, however. Conversely, sex differences were demonstrated for pressure pain tolerance but not for cold. Our null hypothesis was that there would be no differences for either test. Women were more accepting of pain expression than men, neither pain beliefs nor psychosocial factors explained differences in pressure pain tolerance. This was the first characterization of beliefs about the appropriateness of pain expression in an African cohort and the first assessment of these beliefs in relation to pressure pain tolerance anywhere.

Our univariate analyses showed that for both ethnicity groups male participants had greater cold pain tolerance than did females, and within each sex, individuals of European ancestry had a greater cold pain tolerance than their counterparts of African ancestry (Table 2). Both these findings are consistent with those reported by other investigators [1,32], including those comparing cold pain tolerance in African Americans to Europeans [7,33,34]. Between sex and ethnicity, multivariate analysis demonstrated that ethnicity was the most important of these predictors, followed by sex, such that females of African ancestry had the lowest cold pain tolerance, followed by males of African ancestry (Figure 1 and Supplementary Figure 1). Anxiety was identified as a predictor of cold pain tolerance on random forest analysis but only a weak predictor.

There also were similarities between our findings and those of investigators assessing pressure pain tolerance in European and US cohorts [1], such that we found a significant sex effect, with males tolerating higher pressures than did females in univariate (Table 2) and multivariate analyses (Figure 1 and Supplementary Figure 2). Moreover, we found no association between ethnicity and pressure pain tolerance. We are unaware of other studies comparing pressure pain tolerance between different ethnicities, but studies comparing thresholds for pressure pain in Europeans and African Americans also reported no ethnicity differences in sensitivity to mechanical stimuli [33,34].

Differences in cold pain and pressure pain tolerance between the groups in our study were not accompanied by significant differences in the pain intensity reported when tolerance was reached. It is not clear whether groups with lower cold and/or pressure pain tolerance reached their maximum pain intensity sooner than did those with greater tolerance levels, or whether those with greater tolerance levels merely tolerated the pain intensity for longer once the tolerance intensity had been reached. A limitation of our study was that we did not measure pain intensity at regular intervals during the pain tests, including documenting pain threshold, as these data may have highlighted which of these scenarios was the case. We could also have measured pain intensity at set pressures in the pressure test. Future studies should add these additional pain measures for a more comprehensive understanding of responses to experimental stimuli.

Table 3 Attitudes toward females (APBQ-F) and males (APBQ-M) expressing pain*

<table>
<thead>
<tr>
<th></th>
<th>Males†</th>
<th>Females‡</th>
<th>Outcome of post hoc Dunn’s tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>African ancestry (N = 44)</td>
<td>European ancestry (N = 52)</td>
<td>African ancestry (N = 64)</td>
</tr>
<tr>
<td>APBQ-F</td>
<td>3.6 (2.8–4.7)</td>
<td>3.9 (2.3–5.3)</td>
<td>3.2 (1.8–4.7)</td>
</tr>
<tr>
<td>APBQ-M</td>
<td>0.4 (−1.5–2.4)</td>
<td>2.2 (0.8–4.1)</td>
<td>3.2 (1.6–4.3)</td>
</tr>
</tbody>
</table>

Post hoc analyses were performed only if P < 0.05 for KW. APBQ = Appropriate Pain Behavior Questionnaire; KW = Kruskal-Wallis test.

*APBQ scores range from −6 to 6. Negative values indicate pain expression is perceived as inappropriate. Positive values indicate pain expression is perceived as appropriate.
†Missing APBQ-F data from one African ancestry male and nine European ancestry males.
‡Missing APBQ-M data from seven African ancestry females and five European ancestry females.
For tolerance differences between males and females, sex-related differences in the physico-mechanical properties of the hand and fingers may have contributed to the differences we observed, but we do not feel such physico-mechanical factors would have contributed significantly to ethnicity differences within each sex. Elsewhere, a study investigating cold pain tolerance between groups of European ancestry and African Americans also reported no difference in cold pain intensity at tolerance, despite the African American cohort having lower cold pain tolerance [34]. Differences in pain intensity reported at tolerance to a mechanical stimulus have been mixed [1].

Pain catastrophizing is greater in African Americans than it is in Europeans and is associated with reduced pain tolerance [35]. However, mean catastrophizing scores were similar between the two ethnicities [35]. We found no significant differences in pain catastrophizing between groups of African and European ancestry due to ethnicity differences within each sex. Pain catastrophizing is greater in African Americans than it is in Europeans, and is associated with reduced pain tolerance. However, the differences we observed were not statistically significant, and the differences we observed may have contributed significantly to the differences we observed. We do not feel such sex-related differences in the physico-mechanical properties of the hand and fingers may have contributed to the differences we observed. We do not feel such physico-mechanical factors would have contributed significantly to ethnicity differences within each sex. Elsewhere, a study investigating cold pain tolerance between groups of African and European ancestry also reported no difference in cold pain tolerance [34]. Differences in pain intensity reported at tolerance to a mechanical stimulus have been mixed [1].

We also measured the burden of depression and anxiety (Table 4). While the HSCL-25 is not a clinical diagnosis, scores greater than 1.75 indicate a clinically relevant level of anxiety or depression [20]. Subscale scores > 1.75 indicate a clinically significant level of pain catastrophizing [34].

Post hoc analyses were performed only if $P < 0.05$ for KW. Scores > 30 indicate a clinically significant level of pain catastrophizing [34]. Subscale scores > 1.75 indicate a clinically relevant level of anxiety or depression [20]. AAF = African ancestry female; AAM = African ancestry male; EAF = European ancestry female; EAM = European ancestry male; HSCL-25 = 25-item Hopkins Symptom Checklist; KW = Kruskal-Wallis test; PCS = Pain Catastrophizing scale.

*Missing HSCL-25 data for one individual.
†Missing PCS data for two individuals.

### Table 4: Sex- and race-dependent differences in pain catastrophizing, anxiety, and depression

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>African ancestry</td>
<td>European ancestry*</td>
</tr>
<tr>
<td></td>
<td>(N = 44)</td>
<td>(N = 52)</td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>Median (IQR)</td>
<td>Median (IQR)</td>
</tr>
<tr>
<td>PCS score</td>
<td>15 (13–30)</td>
<td>11 (7–18)</td>
</tr>
<tr>
<td>HSCL-25 anxiety score</td>
<td>1.35 (1.10–1.60)</td>
<td>1.40 (1.30–1.50)</td>
</tr>
<tr>
<td>HSCL-25 depression</td>
<td>1.30 (1.15–1.67)</td>
<td>1.20 (1.07–1.33)</td>
</tr>
</tbody>
</table>

Post hoc analyses were performed only if $P < 0.05$ for KW. Scores > 30 indicate a clinically significant level of pain catastrophizing [34]. Subscale scores > 1.75 indicate a clinically relevant level of anxiety or depression [20]. AAF = African ancestry female; AAM = African ancestry male; EAF = European ancestry female; EAM = European ancestry male; HSCL-25 = 25-item Hopkins Symptom Checklist; KW = Kruskal-Wallis test; PCS = Pain Catastrophizing scale.

*Missing HSCL-25 data for one individual.
†Missing PCS data for two individuals.

For tolerance differences between males and females, sex-related differences in the physico-mechanical properties of the hand and fingers may have contributed to the differences we observed, but we do not feel such physico-mechanical factors would have contributed significantly to ethnicity differences within each sex. Elsewhere, a study investigating cold pain tolerance between groups of European ancestry and African Americans also reported no difference in cold pain tolerance [34]. Differences in pain intensity reported at tolerance to a mechanical stimulus have been mixed [1].
sex differences in experimental pain are less convincing [4,39]; however, anxiety was a weak predictor of cold pain tolerance.

This is the first study of experimental pain in sub-Saharan Africa, but whether the results from this study in South Africa can be generalized to the rest of Sub-Saharan Africa remains to be seen and will require further studies across other African countries. While all of sub-Saharan Africa has a history of colonial rule and racial segregation, South Africa has achieved independence from such rule most recently (1994), and there are still extreme wealth, health, and social inequalities between those of European and African ancestry [40,41]. For example, despite our study cohort being drawn from a university population, and thus representing individuals of similar educational attainment and access, we still found differences in each of our socioeconomic status measures including parents’ education, employment, and ownership of assets between the groups of African and European ancestry (Table 1). SES weakly predicted ABPQ-M scores, but, unlike another study [10], SES did not associate with pain tolerance. The relationship between SES and pain may have complex interlinking mechanisms, however, including occupation, education, ethnicity, and coping styles [42]. In addition to differences in SES, we saw ethnic (in addition to sex) differences in depression, anxiety, and catastrophizing. These differences are consistent with the poorer mental health of those of African ancestry reported by Das-Munshi (2016) [43].

Like previous reports, we found that both sex and culture affected how appropriate expressing pain was seen to be. While all groups were equally accepting of females expressing pain, differences were seen in how appropriate it was perceived for men to express pain. First, there was a sex difference, but only between students of African ancestry. While other studies comprising European, Japanese, and Indian participants have found females generally to be more accepting than males of men expressing pain [14,44], females of African ancestry fitted this pattern, but there was no difference between females and males of European ancestry. Secondly, we saw an ethnicity difference. In contrast to lower ABPQ scores given by Indian women compared with American women of European ancestry, South African females of African and European ancestry were similarly accepting of pain expression in males [14]. Additionally, like other non-European groups, males of African ancestry were less accepting than males of European ancestry of men expressing pain [14,44]. However, to put this in context, males of African ancestry had a score close to 0, indicating a neutral opinion about expressing pain. The advantage of using our version of the scoring system for the ABPQ was that we could pick up this subtlety. Indeed, as all groups were relatively accepting of pain expression, we may not have had the range of scores to pick up an association between pain beliefs and pain sensitivity, as seen in the comparison of Indians and Americans [14]. Another limitation of our study was that we only considered sex differences and not gender differences. This would have allowed a more nuanced evaluation of social learning about pain between cultures and how gender role expectations about pain have affected pain tolerance elsewhere [13,45]. Furthermore, the experimenter in this study was female and self-identified as Indian. She was thus ethnicity-neutral to the participants, but her sex may have influenced the pain intensity and tolerance scores of participants. That is, male participants may have displayed greater pain tolerance due to the female
In conclusion, in the first assessment of pain tolerance to two painful stimuli in an African population, we found that students of African ancestry had lower cold pain tolerance than did students of European ancestry and male students had greater pressure pain tolerance than did female students. We hypothesized that because of the different social and cultural background in South Africa, we would see different results compared with studies from the United States; however, our results were the same, suggesting similar contributing factors. Psychosocial factors were identified as weak predictors of cold and pressure pain tolerance and perceptions about the appropriateness of expressing pain. These results require replication in larger cohorts and also those from other sub-Saharan African countries. In addition to the higher levels of depression and anxiety found in females of African ancestry, we also found high levels of catastrophizing in females of African ancestry too. Should this level of catastrophizing form part of a profile of fear-avoidant beliefs, it may predict future risk of chronic pain [39]. If this scenario was the case, non-pharmacological interventions aimed at reducing catastrophic thinking and increasing self-efficacy in females of African ancestry in particular would be warranted.

Author Contributions

LP designed the project, collected the data, completed part of the data analysis, discussed the results with PK and AW, and wrote the first draft of the manuscript. PK helped design the project, completed the rest of the data analysis, assisted with data interpretation, and reviewed the manuscript. AW helped design the project, interpreted the data, and reviewed and edited the manuscript. All authors approved the final version of the manuscript.

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Supplementary Data

Supplementary Data may be found online at http://painmedicine.oxfordjournals.org.

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Predictors of Pain Tolerance in Africans


