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# Muscle pain and blood pressure responses during isometric handgrip exercise in healthy African American and non-Hispanic White adults

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## HIGHLIGHTS

- African Americans experience more pain during exercise than non-Hispanic Whites.
- Muscle pain increases more rapidly during exercise in African Americans.
- Blood pressure responses during exercise are similar in the two groups.

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## ABSTRACT

It has been shown that African Americans (AAs) are more sensitive to experimental pain stimuli compared to non-Hispanic Whites (NHWs). A single bout of exercise results in naturally-occurring muscle pain and elevation in blood pressure (BP); however, it is currently unclear whether AAs and NHWs differ in muscle pain and BP responses during exercise. Therefore, we examined the differences in muscle pain and blood pressure (BP) during isometric handgrip exercise in African Americans (AAs) and non-Hispanic Whites (NHWs). Fourteen AAs and 14 NHWs completed isometric exercise consisting of squeezing a hand dynamometer at 25% of maximal strength for 3 min. During exercise, muscle pain ratings (MPRs) were assessed every 30 s, whereas systolic and diastolic BP (SBP and DBP) were recorded every minute. During exercise, AAs generally reported greater MPR than NHWs ($p < 0.001$), and MPR increased more rapidly during exercise in AAs than NHWs ($p < 0.05$). In contrast, SBP and DBP continued to increase similarly during exercise in both AAs and NHWs ($p > 0.05$). The results suggest that AAs generally experienced a greater intensity of muscle pain than NHWs during isometric handgrip exercise, but both groups exhibited similar elevations in BP during exercise.



## 1. Introduction

Growing evidence from experimental studies indicates that African Americans are generally more sensitive to experimental pain stimuli than other races. For example, previous research indicates that African Americans exhibited lower tolerances to heat, cold, and ischemic pain stimuli [1–6], and rated heat pain stimuli higher [1,4,7] in comparison to non-Hispanic Whites. In addition, a physiological study demonstrates that the nociceptive flexion reflex, a spinal reflex induced by noxious stimulation that is modulated by spinal and supraspinal pain mechanisms (e.g., cerebral cortex, cerebellum, brainstem) [8,9], was elicited with lower intensity electrical stimulation in African Americans compared to non-Hispanic Whites [10]. Furthermore, Campbell et al. [11] examined a conditioned pain modulation consisting of assessing the reductions in electrical pain ratings during concurrent application of ischemic pain, and reported that non-Hispanic Whites exhibited greater reductions in electrical pain ratings during concurrent application of ischemic pain compared to African Americans. Conditioned pain modulation has been found to be mediated by a specific region in the medulla, the subnucleus reticularis dorsalis; therefore, it has also been used to assess the function of central pain modulation [12,13]. Together, these observations collectively suggest that African Americans have higher sensitivity to experimental pain stimuli compared to non-Hispanic Whites, and that this is partly due to an impairment of pain modulatory systems within the central nervous system.

Central pain modulation can also be assessed using other psychophysiological techniques. For example, numerous studies have been conducted examining the association between pain sensitivity and resting blood pressure (BP) in humans and animals, and results indicate an inverse association between pain sensitivity and resting BP [14–16]. Furthermore, previous research indicates that acute elevations in BP, caused by pharmacological or behavioral interventions (e.g., exercise), are also accompanied by reduced sensitivity to experimental pain

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stimuli [17]. Animal research demonstrates that several brain sites (e.g., rostral ventromedial medulla, nucleus tractus solirarius) are involved in the control of both BP and pain, and it has been suggested that elevated BP may initiate descending pain modulation via activation in these brain sites, resulting in decreased pain sensitivity [14,15]. Mechlin et al. examined the relationship between subjective responses to experimental pain stimuli and BP responses in African Americans and non-Hispanic Whites, and found that African Americans did not have an inverse association between pain sensitivity and BP, whereas the inverse association was confirmed in non-Hispanic Whites [4]. Therefore, the results suggest an impaired central pain modulation associated with BP elevations in African Americans.

Exercise is a potent behavioral stimulus that acutely elevates BP [18, 19], and produces naturally-occurring pain in exercising muscles [20, 21]. A previous study demonstrates that even low intensity, short duration isometric handgrip exercise produces significant elevations in BP and a moderate intensity of muscle pain in the exercising forearm in healthy young adults [27]. These observations suggest that submaximal isometric handgrip exercise may be an optimal behavioral stimulus that can be used to examine the racial/ethnic differences in muscle pain and BP responses; however, no study has been conducted to compare muscle pain and BP responses during exercise in African Americans and non-Hispanic Whites. Therefore, the purpose of the present study was to examine whether African Americans and non-Hispanic Whites differ in muscle pain and BP responses during submaximal isometric exercise.

## 2. Materials and methods

### 2.1. Participants

Healthy adults who identified themselves as African American or non-Hispanic Whites were recruited to participate in this study using an advertisement that was circulated via the campus-wide electronic mailing system and study flyers that were posted on designated places for public announcement on campus. The inclusion criteria for this study were 1) 18 to 30 years of age, 2) self-identification as African American or non-Hispanic White, 3) no medical conditions diagnosed by their physician, and 4) no medication use. Subjects were excluded from the study if 1) they indicated medical contraindications for exercise, 2) they were pregnant or breastfeeding at the time of screening, or 3) they were unable to understand instructions in English. The two groups were matched based on age ($\pm$3 years) and gender. The study protocol was fully approved by an institutional review board, and all participants signed a consent form before participating in the study.

Power analysis was performed to estimate a sample size necessary to detect significant group differences in muscle pain during exercise in African Americans and non-Hispanic Whites. To perform the analysis, effect size (Cohen's d) was first calculated based on our pilot data, and the calculated effect size ($d = 1.2$), an $\alpha = 0.05$, and a power $= 0.80$ were then used for the analysis [22]. The power analysis indicated that approximately 12 African Americans and 12 non-Hispanic Whites would be needed for the study.

### 2.2. Procedures

The participants were asked to visit our laboratory once to complete a study session examining muscle pain and BP responses during isometric handgrip exercise. All study sessions were conducted by trained staff between 0900 and 1800 h, and the participants were asked to refrain from 1) strenuous exercise for 12 h, 2) alcohol consumption for 12 h, 3) caffeine intake for 3 h, and 4) smoking for 2 h before the study to accurately assess resting BP [23,24].

Upon arrival at the lab, the participants were first asked to sign a consent form, and then to complete questionnaires regarding demographics and general health, and regular physical activity (PA) levels using the Baecke Physical Activity Questionnaire (BPAQ) [25]. The BPAQ is a validated self-report questionnaire to quantify PA levels, and it consists of three subscales to estimate work-, sport-, and leisure-related PA [25,26]. The work-related PA subscale assesses the type of occupation and the activity levels associated with their occupation. The sport-related PA subscale quantifies the amount of PA the participants are recreationally engaging in, whereas the leisure-related PA subscale quantifies the amount of PA except for recreational PA. Therefore, the leisure-related PA includes, for example, activities associated with the participants' daily commuting and TV-viewing. Each subscale quantifies the specific domain of PA, and total scores from the three subscales represent the participants' total PA levels.

The investigator then prepared the participants for assessment of their resting BP by placing three electrodes on their chest and attaching a BP cuff around their non-dominant upper arm. Both electrodes and the BP cuff were connected to a small ECG device (Tango+, SunTech Medical, NC) that allowed the investigator to monitor BP periodically during the session. The participants were asked to remain seated in a comfortable chair for several minutes, and the investigator then assessed the participants' resting BP. Next, the investigator explained the exercise protocol to the participants, and then instructed them how to use the muscle pain rating (MPR) scale [20]. After the participants demonstrated understanding of the MPR scale with no further questions, they were informed that they would be rating muscle pain every 30 s during the exercise protocol. The participants were specifically instructed to rate the intensity of painful sensation in their forearm during exercise using the MPR scale. The MPR scale is constructed in a vertical alignment with 12 numbers (MPR 0, ½, 1–10), and has the corresponding verbiage next to nine numbers. The MPR scale ranges from no pain at all (MPR = 0) to extremely intense pain (MPR = 10), and also includes an unbearable pain option after the 10 rating if the participant experiences pain that exceeds the rating of extremely intense pain. The participants were then asked to squeeze a hand dynamometer (Model 78010, Lafayette Instrument, IN) with their dominant hand as hard as possible to assess their maximal voluntary contraction (MVC). The MVC assessment was conducted twice with sufficient rest between the trials, and the average of the two trials was used to compute 25% MVC for the subsequent exercise session. The participants were then asked to squeeze the hand dynamometer at 25% MVC and hold it at the target intensity as well as possible for 3 min. During this exercise, the investigator assessed MPR every 30 s, and BP every min. This exercise protocol was used because a previous study demonstrated that isometric handgrip exercise at 25% MVC for 3 min produces a moderate intensity of muscle pain in the forearm and significant elevations in BP in healthy adults [27]. The entire session took approximately 40 min to complete.

### 2.3. Data analyses

The BPAQ was scored based on the published scoring method [25], and body mass index (BMI) was calculated using the following formula: $\text{BMI} = \text{weight (kg)} / (\text{height (m)})^2$. Age, BMI, MVC, the BPAQ scores, and resting BP were compared between African Americans and non-Hispanic Whites using an independent sample t-test to examine group differences in these variables.

To test our primary hypotheses regarding whether African Americans would differ from non-Hispanic Whites in muscle pain and BP responses during isometric handgrip exercise, the MPR data were analyzed using a 2 (group: African American and non-Hispanic White) $\times$ 6 (time: every 30 s during 3 min of exercise) mixed model of repeated measures ANOVA, whereas the BP data were analyzed using a 2 (group: African American and non-Hispanic White) $\times$ 3 (time: every min during 3 min of exercise) mixed model of repeated measures ANOVA. Effect size was calculated using Cohen's d to assist in accurate interpretation of significant interaction effects where appropriate. Effect size was interpreted based on the following guideline: small effect = 0.2, medium effect = 0.5, and large effect = 0.80 [22].