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Effects of progressive muscle relaxation training on nociceptive flexion reflex threshold in healthy young adults: A randomized trial

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Abstract

Although prior studies have demonstrated effects of progressive muscle relaxation (PMR) in reducing self-reported pain, no laboratory studies have examined the effects of PMR on objective indicators of descending modulation of nociception. This randomized controlled study utilized the nociceptive flexion reflex (NFR) to evaluate nociceptive responding among 55 college-age men and women (mean age = 19.4 ± 1.2 years). Participants completed laboratory assessments of NFR threshold and questionnaires evaluating pain and stress. Participants were then randomly assigned to either a 25-min PMR condition or a no-treatment control condition. Following the brief intervention, participants completed a second NFR procedure and self-report questionnaires. Results indicated a significant time by condition interaction for NFR, with participants in the PMR condition experiencing a significant increase in NFR threshold while participants in the no-treatment condition experienced no change in NFR. Ratings of pain did not change during the study, but PMR participants reported decreased stress following the PMR intervention. This is the first study with a randomized no-treatment control group demonstrating the effect of a brief PMR protocol on descending inhibition of nociception. Results support the efficacy of PMR in reducing nociceptive response and provide further evidence of the utility of behavioral pain management strategies.

Keywords: Nociception; Progressive muscle relaxation; Nociceptive flexion reflex

1. Introduction

Prior research has demonstrated beneficial effects of progressive muscle relaxation (PMR) in reducing osteoarthritis pain [10], chronic headache pain [2], and cancer-related pain [22]. The analgesic effect of PMR is thought to result when decreased afferent neural impulses from the skeletal musculature contribute to reduced sympathetic activity [1] and to reduced activity of neuromuscular circuits associated with the experience of pain [15]. PMR also relieves tension in accessory muscles that may contribute to the experience of pain. However, studies have not further evaluated the mechanism by which PMR influences pain, and prior studies have relied primarily on subjective ratings of pain. No studies have evaluated the effect of PMR on an objective indicator of nociceptive responding such as the nociceptive flexion reflex (NFR).

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The NFR is a polysynaptic spinal reflex used in prior studies examining pain processing [4,7,21]. When elicited by electrical stimulation applied to the foot, the NFR can be recorded via electromyography (EMG) of the hamstring muscles of the upper leg. Stimulation intensities sufficient to activate small diameter (i.e., A-delta) fibers can evoke change in EMG activity corresponding to a nociceptive withdrawal response. The NFR is relatively stable across assessments, with test-retest measurements ranging from 0.55 to 0.81 when recorded up to 24 h apart [9,19]. However, thresholds have been found to increase in response to pain medication, TENS, acupuncture, and hypnosis [21]. Further, in a recent study, brief cognitive coping skills training (CST) was associated with significant acute increases in NFR threshold among older adults with osteoarthritis [6]. Because PMR training was a central component of the CST intervention, and because of the efficacy of PMR in reducing subjective pain ratings in prior studies, it was of interest to evaluate the extent to which PMR alone might influence central nociceptive responding.

The purpose of the present study was to evaluate the influence of PMR on NFR in a non-clinical population. There were several reasons for pursuing this line of investigation. First, PMR is a shorter intervention than CST and generally less complicated both for instructors to teach and for patients to learn. Second, the prior study of osteoarthritis patients was conducted to evaluate sex differences and did not include a randomized no-treatment control group [6]. To clarify the efficacy of behavioral interventions for influencing central nociceptive responding, it was important to replicate the previous study using a randomized no-treatment control group.

This laboratory-based study recruited healthy college-age adults with no history of chronic pain disorder to determine the effect of relaxation training on nociception without introducing the increased variability of pain response that would be likely in a clinical sample. The study evaluated the effect of a single-session relaxation training intervention on NFR threshold, pain ratings, and stress. The single-session format was utilized to facilitate evaluation of acute changes in NFR following the intervention. Based on results of the prior study of patients with OA [6], it was hypothesized that PMR would be associated with increased NFR threshold and reductions in ratings of pain and stress.

2. Methods

The study sample included healthy young men ($n = 26$) and women ($n = 29$) with a mean age of 19.4 (± 1.2) years (range: 18–23 years). The sample was predominantly Caucasian (83.6%; African–American 5.0%, Asian 8.5%, Native American 1.7%). The following exclusion criteria were utilized: (1) age less than 18 years or more than 25 years, (2) history of chronic pain or migraines, (3) morbid obesity (body mass index $\geqslant 40$), (4) regularly using pain medications and unwilling to abstain from taking them 24 h prior to the study, (5) failure to demonstrate a pain reflex during the initial NFR procedure described below, or (6) self-reported maximal pain rating during the experiment. Among participants who met full criteria for the study, one reported a chronic pain disorder following the baseline assessment and thus was never randomized. The resulting sample consisted of 55 healthy young adults who were randomly assigned to either the PMR condition or a no treatment control group.

Potential participants were recruited through the Research Experience Program at Ohio State University. Prospective participants completed an initial pre-screening questionnaire during which they were told that the study was being conducted to evaluate responses to a painful electrical stimulus. Prospective participants also were told that they would be provided with brief training in coping with pain. Interested individuals who met study criteria were scheduled for participation. Participants were asked to refrain from using analgesic medication prior to the medical appointment. Upon arriving for the appointment, informed consent was obtained from all participants.

2.1. Procedure

2.1.1. Preliminary measures

Participants completed a brief prescreening questionnaire to assess adherence to the requested medication restrictions, followed by measurements of height, weight, and resting blood pressure. Electrical stimulation and EMG recording sites were prepared and the participants completed the NFR procedure described below.

2.1.2. NFR apparatus and materials

Stimulation and recording sites were cleaned and abraded with Omni Prep electrode paste, and an impedance of less than 10,000 Ohm was verified using a UFI Checktrode. To produce the stimulation required to elicit the NFR, a Nicolet bar electrode (anode inferior) was attached to the left leg over the retromalleolar pathway of the sural nerve. Electrical stimulation was delivered using a Digitimer, DS7A constant-current stimulator. To record NFR activity, a DelSys Bagnoli-2 EMG amplifier was used with a differential EMG electrode attached over the left biceps femoris muscle, 10 cm superior to the popliteal fossa. An EMG reference electrode was attached over the lateral epicondyle of the femur. EMG activity was recorded and processed using a Data Translation DT21-EZ analogue-to-digital converter, a personal computer, and a specially designed BASIC program.

After electrical stimulation and EMG recording sites were prepared, the participants were seated in a Hi-Seat rehabilitation chair with the leg rest adjusted to maintain left knee flexion at approximately 60 deg from horizontal. While seated, participants were given two Visual Analogue Scales to rate their current pain (VASP) and stress (VASS). This was followed by an assessment of resting blood pressure. Electrical stimulation was then applied over the sural nerve. Each stimulation trial consisted of a volley of five 1-ms rectangular pulses with a 3-ms interpulse interval (total duration = 17 ms). Using an up-down staircase method [13], stimulation intensity was increased in increments of 4 mA until an NFR was detected (or a maximum intensity of 40 mA was reached) and then decreased in incre-