Scandinavian Journal of Pain 3 (2012) 165–169

Contents lists available at SciVerse ScienceDirect

Scandinavian Journal of Pain

journal homepage: www.ScandinavianJournalPain.com

Original experimental

Cardiovascular responses to and modulation of pressure pain sensitivity in normotensive, pain-free women

Christine Mohn[a,b,*], Olav Vassend[a], Stein Knardahl[c]

[a] Department of Psychology, University of Oslo, Norway
[b] Department of Research, Vestre Viken Hospital Trust, Norway
[c] Department of Work Psychology and Physiology, The National Institute of Occupational Health, Oslo, Norway

ARTICLE INFO

Article history:
Received 9 September 2011
Received in revised form
25 November 2011
Accepted 19 December 2011

Keywords:
Blood pressure
Cardiovascular responding
Heart rate
Pain sensitivity
Pressure pain
Skin blood flux

ABSTRACT

Background and purpose: The psychophysiological responses to and modulation of pressure pain stimulation are relatively new areas of investigation. The aims of the present study were to characterize subjective and cardiovascular (CV) responses to pressure pain stimulation, and to examine the relationship between CV responding and pain pressure pain sensitivity.
Methods: Thirty-nine pain-free, normotensive women were included in the study and tested during the follicular phase of their menstrual cycles. Pain threshold and tolerance were recorded at the right masseter muscle and the sternum, and visual analogue scales (VAS) were used to rate both pain intensity (the sensory dimension) and discomfort (the affective dimension). Mean arterial pressure (MAP), heart rate (HR), and facial and digital skin blood flux (SBF) were registered continuously.
Results: The pain threshold and tolerance were significantly higher at the sternum compared with the masseter, but the level of affective distress was higher at the masseter tolerance point. No associations emerged between pressure pain threshold and tolerance stimulation levels, and the corresponding VAS ratings. Pressure pain stimulation of the masseter induced significant increases in MAP, HR, and a decrease in digital SBF. During sternum pressure stimulation a significant change in HR and digital SBF was observed. There were no significant correlations between CV responding and pressure pain sensitivity.
Conclusion: Healthy women seem to display higher pressure pain sensitivity at the masseter region relative to the sternum. Pressure pain stimulation was associated with significant changes in MAP, HR, and SBF, but was not modulated by CV responses. The validity of these findings is strengthened by our control for menstrual cycle events, weekend-related changes in physiology, and CV changes during pain stimulation.
Implications: This study extends previous reports of SBF sensitivity to electrocutaneous pain into the field of pressure stimulation. Moreover, this study suggests that the often demonstrated association between high BP and low pain sensitivity may not apply to pressure pain specifically. Alternatively, this finding adds to the literature of gender differences in the relationship between CV responding and acute pain sensitivity in general.

1. Introduction

The mulitidimensional nature of pain perception requires the assessment of several aspects of the pain experience. In order to obtain as complete a picture as possible of the individual's pain experience, subjective and physiological responses to pain stimulation should be described in addition to the pain sensitivity thresholds. Compared with other stimulation methods such as thermal pain [1], the Subjective and physiological responses to pressure pain are not well known.

As substantiated in previous research, measurements of skin blood flux (SBF) may provide valuable indicators of autonomic nervous system (ANS) activity during psychological challenges [2,3]. Moreover, electrocutaneous pain stimulation seems to trigger increases in facial SBF as well as decreases in digital SBF [4,5]. Similar orofacial SBF changes during pain stimulation have been documented by Kemppainen et al. [6,7]. However, as the research on SBF during pain in humans is relatively new, few studies of SBF responses to experimental pain exist.

In both normotensive and hypertensive individuals, elevations of arterial pressure may be associated with reduced sensitivity to painful stimuli [8,9]. Although the CV–pain relationship appears

DOI of refers to article: 10.1016/j.sjpain.2012.02.005.
* Corresponding author at: Department of Psychology, University of Oslo, PO Box 1094, Blindern, 0317 Oslo, Norway. Tel.: +47 22 84 51 15; fax: +47 22 84 50 01.
E-mail address: christinemohn@hotmail.com (C. Mohn).

1877-8860/$ – see front matter
doi:10.1016/j.sjpain.2011.12.001

attenuated or absent altogether in chronic pain groups [10,11], we have recently found that elevated mean arterial pressure (MAP) was associated with reduced pain sensitivity in women with TMD, but not in the pain-free control group [12]. That study employed electrocutaneous and pressure stimulation, whereas the others [10,11] assessed thermal and ischemic pain. Different pain stimulation methods are likely to induce different behavioural, autonomic, and antinociceptive responses [4,13,14].

Moreover, in our previous study of electrocutaneous pain [12] we did not control for certain factors that may modulate pain sensitivity, CV responding or the relationship between those two. These include hormonal effects of menstrual cycle events on pain sensitivity [15] and weekend-related changes in physiology [16]. In addition, the fact that pain stimulation may generate BP increases in its own right could confound the relationship between baseline CVR and subsequent pain sensitivity assessments [17]. Therefore, we control for these factors in the present study.

The general rationale behind this study was to extend previous work on psychological and physiological responding during experimental pain in general to pressure pain stimulation in particular. The primary aim is to characterize subjective and physiological responses, including facial and digital SBF, to pressure pain stimulation. The secondary aim is to examine the relationship between CV responses and pressure pain sensitivity while controlling for possible confounders.

2. Materials and methods

2.1. Subjects

Thirty-nine Caucasian women (see Table 1 for demographic characteristics) were recruited among graduate students of medicine and psychology of the University of Oslo via the students' mailing lists. Inclusion criteria were age between 20 and 50 years, and ability to speak and understand spoken and written Norwegian. Exclusion criteria (self reported) were known hypertension, chronic pain, general chronic somatic or mental health problems, pregnancy, and use of regular medication apart from oral contraceptives. The subjects were instructed to refrain from drinking alcohol the last 12 h before the experiment, and to avoid drinking tea or coffee, having large meals, and exercising the last 3 h before the experiment. All subjects were tested in the follicular phase of their menstrual cycle in order to rule out pain sensitivity effects of different endogenous reproductive hormone levels [15]. In order to avoid physiological effects of excessive alcohol and/or tobacco consumption during weekends, no experimental testing took place on Mondays [16]. The present study was conducted in accordance with the Helsinki Declaration and approved by the regional Medical Ethics Committee. All subjects gave their informed consent to the participation, and were informed that they were able to withdraw from the experiment at any time. All subjects received a gift-voucher at the price of 250 NOK (approximately USD 45, September 2011) as compensation for time loss.

Table 1
Demographic characteristics.

Age	24.8 (SD 3.9) years
Body mass index	20.9 (SD 3.4)
Regular physical exercise	85.0%
Smoking	15.0%
Married/cohabiting	43.9%
Divorced/separated	None
Children living at home	2.4%

Age and body mass index in mean. $N = 39$.

2.2. Instruments

Threshold and tolerance of pressure pain: Pressure pain was measured by a pressure algometer (Somedic, Sollentuna, Sweden), with a 1 cm^2 diameter probe. The rate of pressure increase is standardized by visual feedback provided by the algometer and was set at 50 kPa/s. Pressure algometry was applied perpendicularly to the central part of the right masseter muscle and the sternum. The subjects were asked to raise their right index finger when the pressure became painful (threshold). Furthermore, the subjects terminated the test by pressing a button when the stimulation became so intense that they wanted to interrupt it (tolerance).

Psychological responses to the pain stimulation: Immediately after each pain stimulation trial, the subjects rated pain intensity (VAS-S, VAS sensory) and discomfort (VAS-A, VAS affective) at threshold and tolerance [13]. This assessment was done by a continuous 100 mm electronic visual analogue scale (eVAS) with the anchors "no pain at all" at the left end and "the worst pain I can imagine" at the right end. The participants rated their pain experience in this way immediately after the pain stimulation trial. They were asked to rate the pain intensity at the threshold level, then pushed the button back to 0, and then rated the pain discomfort at the threshold level, and pushed the button back to 0. The rating of intensity and discomfort at the tolerance level was done in the same manner.

Cardiovascular recordings: MAP and heart rate HR were continuously monitored by the Peñaz method (Ohmeda 2300, Englewood, CO, USA). A cuff containing a photoelectronic sensor was attached to the middle phalanx of the third finger on the subjects' left hand. The subjects' hand was placed on a padded armrest in order to keep it positioned at the same level as the heart.

Laser-doppler skin blood flux (LDF) changes were recorded with a Perimed Multichannel Laser Doppler System (PeriFlux 4001 Master, Perimed, Sweden). Miniature probes (Perimed, Sweden) were attached to the left m. masseter area and to the ventral side of the left thumb. This instrument expresses SBF in arbitrary units, proportional to the velocity and concentration of red blood cells moving in the superficial layer of the skin. Although it is customary to present SBF data as percentages of change from baseline, we report the arbitrary levels of flux to be able to perform within-subject statistical analyses [4].

All signals were AD-converted, recorded, stored and reduced in a computer (Lab View, National Instruments, Austin, TX, USA).

2.3. Procedure

The psychophysiological experiment took place in a sound attenuated and electromagnetically shielded laboratory with the temperature kept constant at 22 °C. The subjects were seated in an upright position in a comfortable, upholstered chair. The experimenter described the function of the instruments and sensors, and was present in the room during the entire experiment. The subjects learned to interrupt the pain stimulation through one trial of pressure pain stimulation at both anatomical sites.

The experiment lasted 30–40 min and consisted of randomized sequences of pressure stimulation at the masseter and sternum. All subjects went through three pressure stimulation trials at the right masseter muscle and three pressure stimulation trials at the sternum. Two-minute resting periods between each trial were provided to ascertain that the physiological responses returned to baseline before the next trial.

2.4. Data analysis

All statistical analyses were made using SpSS, release 16 (SpSS Inc., Chicago, IL, USA). The correlations between the three measurements of pain threshold and tolerance at both sites were high (i.e.,