Jaw Clenching Modulates Sensory Perception in High- But Not In Low-Hypnotizable Subjects

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Aims: *To investigate the effect of jaw clenching on the sensations evoked at segmental and nonsegmental levels by painful and nonpainful stimuli and in relation to hypnotic susceptibility.* ***Methods:*** *The effect of jaw clenching on painful and nonpainful sensations on the face and leg was studied in high-hypnotizable (HH) and low-hypnotizable (LH) subjects. Sixteen healthy subjects were selected and assigned to either the HH group (n = 8) or the LH group (n = 8). Painful and nonpainful electrical stimuli were delivered in random order to the face and leg. The subjects rated the intensity of the evoked sensation on a visual analog scale (VAS) while clenching or not clenching their jaw.* ***Results:*** *Jaw clenching significantly attenuated the VAS sensory ratings of all the subjects under various conditions (F_{1-31} = 6.15, P < .02). When the HH and LH subjects were analyzed separately, jaw clenching was found to be effective in reducing sensations only in the HH subjects (F_{1-15} = 8.30, P = .01), only those evoked in the face (segmental level), and only those evoked by nonpainful stimuli (tied Z = 2.52, tied P < .02).* ***Conclusion:*** *Sensory modulation produced by jaw clenching may be related to hypnotic susceptibility. On the whole, jaw clenching had a weak, local effect in modulating sensation, in contrast to its known widespread effect on motor behavior.* J OROFAC PAIN 2005;19:76–81

Key words: heterotopic stimulation, hypnotic susceptibility, jaw clenching, pain modulation, sensory modulation

It is widely believed that jaw clenching can relieve pain, and biting on a wooden block has been described in folk medicine as a means of reducing surgical pain without anesthesia. Voluntary clenching of the teeth can exert remote facilitation at cortical and spinal sites, modulate motor behavior, and increase the amplitude of soleus and flexor carpi H reflexes.[1,2] Jaw clenching can also affect sensation. Isometric jaw clenching has induced a significant elevation of perception thresholds to electrical stimulation on facial skin but not on the dorsum of the hand.[3] However, the effect of jaw clenching on the perception of painful stimuli, particularly in remote body areas, has not been studied.

In contrast to jaw clenching, the effect of painful stimuli delivered to 1 part of the body on suppression of pain perception in remote locations has been studied extensively.[4–9] In experimental animals, noxious, but not innocuous, stimuli produce widespread inhibition of nociresponsive neurons in the spinal and trigeminal dorsal horns, a phenomenon termed *diffuse noxious inhibitory controls (DNIC)*.[10–12] The same noxious stimuli also reduce the expression of molecular markers of nociception[13] and reduce pain-related behavior, such as that evoked in the tail-flick test.[14–17]

Recently, Sandrini et al[18] suggested that hypnosis uses the same descending inhibitory pathways as DNIC for the control of pain. Kiernan et al[19] and Danziger et al[20] demonstrated the involvement of descending inhibitory controls during hypnosis in humans but concluded that the activation of descending modulation is not the sole mechanism involved (see also Price[21]). Pain perception can also be influenced by nonpainful, nonpharmacological modalities such as distraction of attention, stress, placebo, and other psychological manipulations.[22–26]

Distraction of attention can be divided into 2 main categories; *cognitive,* where pain responses are modified by changes in the subject's state of belief and expectation, and *noncognitive,* where the modifications can be produced by other factors, such as painful stimuli. While there are ample examples of cognitive manipulation, little is known about noncognitive stimulation that is not painful, particularly in relation to hypnotic susceptibility. Friederich et al[27] and Freeman et al[28] showed evidence that hypnotic analgesia and distraction of attention use different mechanisms of pain control. Hypnotic susceptibility is an innate trait.[21] High-hypnotizable (HH) and low-hypnotizable (LH) individuals differ from one another in their ability to produce analgesia under hypnotic induction.[21,29] It is not known, however, whether HH and LH subjects differ *a priori* in their modulation of sensations evoked by nonnoxious stimulation, such as jaw clenching.

With these considerations in mind, the possible attenuation of the sensory responses to painful and nonpainful stimuli during jaw clenching in HH and LH subjects was examined. Answers were sought for the following questions: *(1)* Can jaw clenching reduce sensations to painful and nonpainful stimuli? *(2)* Does clenching have a differential effect on sensation in HH and LH subjects? *(3)* Does jaw clenching act differentially at the segmental and remote levels? Thus, the effect of jaw clenching on the sensations evoked at the segmental and nonsegmental levels by painful and nonpainful stimuli and in relation to hypnotic susceptibility was studied.

Materials and Methods

Subjects

Paid volunteers were recruited through an "experiment on pain and hypnosis" bulletin board in the local campus of the university. All subjects were generally healthy. None suffered from temporomandibular disorders, and none took any medications during the month prior to the experiment. Subjects freely consented to participate in the experiments. The Ethical Committee of the Hebrew University Hadassah Medical Center approved the study but instructed the authors to include a maximum of 16 subjects. The Stanford Hypnotic Arm Levitation Induction and Test (SHALIT)[30] was applied. Sixteen (8 males, 8 females) out of 44 screened subjects were selected. Subjects were excluded for various reasons, such as being on medication or displaying anxious behavior during screening. The 16 subjects selected were divided into LH and HH groups based on "elbow-raising" during the SHALIT test, meaning that during 6 minutes of hypnotic arm levitation induction, HH subjects disconnected their elbow from the table. The elbow raising criterion correctly classifies 85% of subjects into upper or lower hypnotizable groups on the Stanford Hypnotic Susceptibility Scale, Form A (SHSS:A).[30] It was effective in selecting HH subjects in previous studies[31,32] and clearly differentiated between HH and LH subjects.[32] The LH group consisted of 8 subjects (5 males, 3 females; mean age 23.1 years, range 21 to 26 years), and the HH group of 8 subjects (3 males, 5 females; mean age 23.3 years, range 21 to 25 years). The participants were informed that they were suitable for the study, but were not advised whether they were HH or LH subjects, so as not to bias their expectation for analgesia.

Electrical Stimuli

Electrical stimuli were delivered via a pair of surface electrodes placed 2 cm apart on scrubbed, degreased skin as follows. Stimuli were delivered at 2 sites: *(a)* the right mental nerve (1.5 ms duration) on the skin overlying the nerve at the anterolateral third of the mandible and *(b)* the right sural nerve at the ankle on the skin overlying the nerve at the retromalleolar area. The stimuli to the sural nerve consisted of a train of 20 pulses (each of 0.45 ms duration, interpulse interval 0.58 ms) delivered over 20 ms, from a constant current stimulator (Iso-Flex AMPI). A pair of electromyographic (EMG) surface electrodes (P-511-K; Grass Recorder) was placed 2.5 cm apart on the skin, parallel to the long axis of the superficial masseter muscle, contralateral to the stimulated side, with the ground reference electrode positioned on the neck. EMG activity was monitored to make sure that the participant maintained a constant clench during the experiment.

Sensory and pain thresholds were determined according to the method of limits. Two stimulus values were determined for each subject: *(a)* "Nonpainful," the midpoint between sensory detection and pain threshold, and *(b)* "Painful," twice the pain threshold. Each of the stimulus intensities was delivered 4 times in random order for a total of 8 stimuli per location. The experimenter who delivered the stimuli was blind to the hypnotic susceptibility of the subjects.

Assessment of Sensation and Expectation

After each stimulus the subject graded the intensity of the sensation evoked on a 10-cm visual analog scale (VAS). The endpoints on the scale were marked "no sensation" and "strongest possible sensation." At the end of the screening procedure, subjects were asked to estimate how much they expected to achieve analgesia by means of their hypnotic ability on a scale of 0 (no ability at all) to 10 (the highest ability possible).

Experimental Design

The experimental sessions were carried out under 4 experimental conditions: face (local) stimulated with and without clench, and leg (remote) stimulated with and without clench. The order of these conditions was randomly counterbalanced for location and clench.

The subjects also participated in other experiments involving pain and hypnosis.[32] Some of the other experiments were performed before and some after the cited ones. However, all the other experiments were randomized and counterbalanced, and the subjects received identical preliminary instructions in each experiment so as not to bias the results.

Subjects clenched on a wooden bite stick (5 × 1 × 1 cm) held between the molar teeth. Subjects were trained to clench at the requested level (about 50% of maximum bite force) by monitoring the EMG activity displayed on the oscilloscope. One to 2 seconds prior to a given stimulus, the subject was told by the experimenter "now" (for a no-clench situation) or "clench." The instruction "clench" meant to clench simultaneously with the stimulus. Following each stimulus, the subject relaxed and graded the intensity of the sensation on the VAS scale. The interval between stimuli was 30 to 45 seconds.

Data Analysis

VAS intensity ratings of painful and nonpainful sensations served as a dependent variable. Repeated-measures analysis of variance (ANOVA) was used to analyze the overall effect of jaw clenching. The Wilcoxon signed rank test was used to compare the effect of clenching within the HH and LH groups. The Mann-Whitney test was used to compare expectation rates between the 2 groups. For all tests, the significance level was set at $P \leq .05$.

Results

Jaw Clenching and Sensory Modulation

The overall effect of jaw clenching was analyzed for all subjects (HH and LH) on both locations (face and leg) under both stimulus intensities (painful and nonpainful). It was found that jaw clenching significantly decreased the VAS rating ($F_{1-31} = 6.15$, $P < .02$).

The effect of hypnotizability was further analyzed in HH and LH subjects. The VAS rating was significantly reduced in the HH subjects ($F_{1-15} = 8.30$, $P = .01$) but not in the LH subjects ($F_{1-15} = 1.71$, $P = .21$).

The effect of location was analyzed in both groups. It was found that jaw clenching significantly reduced sensations in the face ($F_{1-15} = 4.34$, $P = .05$), but not in the leg ($F_{1-15} = 1.82$, $P = .2$).

Hypnotic Susceptibility and Jaw Clenching

Nonpainful Stimuli. VAS ratings in response to nonpainful stimuli were significantly reduced in the face during jaw clenching in HH subjects (tied Z = 2.52, tied $P < .02$, Wilcoxon signed rank), but not in LH subjects (tied Z = 0.85, tied $P > .40$). Under the same conditions no effect was observed on the leg in HH or LH subjects (Z = 0.84, tied $P > .40$, and tied Z = 1.4, tied $P > .17$, respectively) (Fig 1).

Painful Stimuli. Jaw clenching in response to painful stimulation did not affect VAS intensity ratings in HH subjects in either the face (tied Z = 0.14, tied $P > .8$) or the leg (tied Z = 1.18, tied $P > .20$). No clenching effect was observed in LH subjects (tied Z = 0.84, tied $P > .4$ in the face, tied Z = 0.08, tied $P > .9$ in the leg) (Fig 1).

Expectation

Subjects were not told whether they belonged to the HH or to the LH group in order not to bias

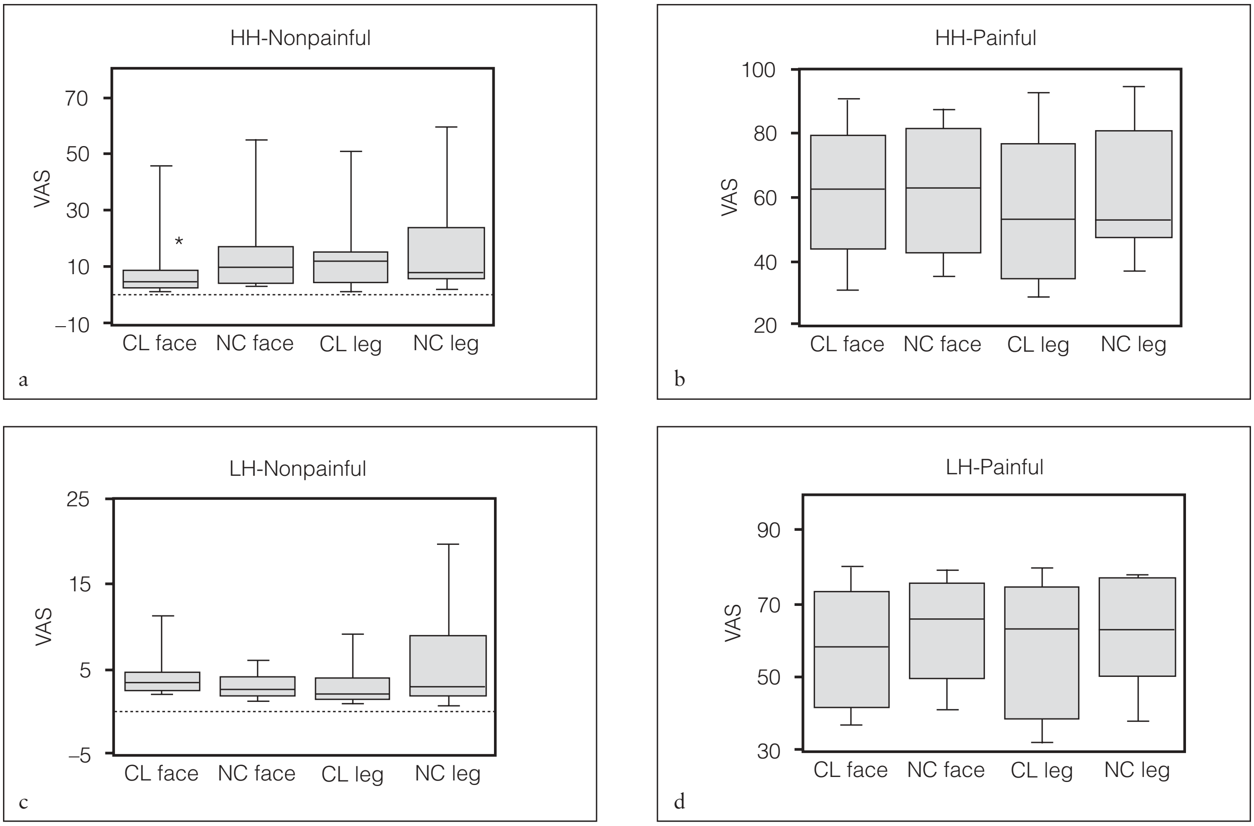

Fig 1 Box plot (10th, 25th, 50th, 75th, and 90th percentiles) showing the effect of jaw clenching on the intensity of sensations (VAS) evoked in the faces and legs of HH and LH subjects by nonpainful and painful stimuli. *(a)* The effect of jaw clenching in HH subjects on responses to nonpainful stimuli. Note that tooth clenching significantly reduced the sensory rating only in the face (*$P < .02$). *(b)* The effect of jaw clenching in HH subjects on responses to painful stimuli. *(c)* The effect of jaw clenching in LH subjects on responses to nonpainful stimuli. *(d)* The effect of jaw clenching in LH subjects on responses to painful stimuli. CL = clench; NC = no clench.

expectation. No difference was found at screening between LH (5.6 ± 0.42) and HH (6.4 ± 0.37) subjects (Mann Whitney; U = 0.66, $P = .51$) in the expectation to achieve analgesia.

Discussion

In the present study, jaw clenching significantly attenuated VAS sensory ratings when analyzed for the entire study sample under the various experimental conditions. This clenching had a local effect only in response to weak, nonpainful stimulation, in contrast to the known widespread effects of jaw clenching on motor behavior.[1,2] When HH and LH subjects were analyzed separately, jaw clenching was effective in reducing sensations only in the HH subjects. Further analysis revealed that this effect took place only at the segmental level (face) and only for nonpainful stimuli. Jaw clenching did not affect VAS ratings for painful stimuli in any of the subjects.

Kemppainen et al[3] found that voluntary jaw clenching significantly elevates perception thresholds to electrical stimulation in the facial skin but not in remote areas (the dorsum of the hand). The participants in their experiment were a group of human volunteers not selected for hypnotic ability. This is comparable to the HH and LH groups combined in the present study, in which a significant change in sensory ratings in response to nonpainful stimulation of the face but not of the leg was found. As already mentioned, jaw clenching did not have any effect in the LH group; therefore, it is possible that the observed attenuation of sensation by jaw clenching in the experiment was related to hypnotic susceptibility.

Hypnotic susceptibility is an innate quality unrelated to other nonpharmacologic modalities such as expectation and placebo effects. The placebo effect affects HH and LH subjects similarly.[21] In addition, expectation was also similar in our 2 groups of HH and LH subjects and therefore does not appear to be related to this differential effect of jaw clenching. It was therefore surprising to find that the local, weak modulatory effect of jaw clenching acted differentially in HH and LH subjects. It can therefore be concluded that HH and LH subjects differ *a priori* in their ability to modulate sensation by jaw clenching. This finding sheds new light on the nature of the sensory modulatory effect of jaw clenching, differentiating it from placebo and expectation effects.

Attention and Hypnotic Susceptibility

Jaw clenching reduced nonpainful sensations in HH subjects in the facial area but not in the leg. It is possible that clenching focused attention on the facial area and that this was responsible for the reduced sensation in the face of HH subjects but not in LH subjects. Usually, when subjects direct attention *away* from a painful stimulus, they rate pain sensation as being lower.[22] However, hypnotic analgesia does not act by diversion of attention.[21] Under hypnosis, focusing attention to the part of the body to be relieved of pain has been reported to be the most effective method of analgesia.[32,33] Interestingly, if this is true, focusing of attention may be sufficient on its own to reduce sensations evoked by weak stimuli in HH subjects.

Painful and Nonpainful Stimuli

During jaw clenching in the present study, HH and LH subjects differed in their responses only to low-intensity stimuli in the facial area but not to high-intensity stimuli. On the other hand, under hypnotic analgesia, the difference between HH and LH subjects is more pronounced at higher stimulus levels than at lower, nonpainful levels.[21,32] It appears, therefore, that the mechanisms operating during jaw clenching in HH subjects differ from those induced by hypnotic suggestion for analgesia.

Previous studies[6,34] indicated that isometric exercise of the limbs or jaw clenching[3] decreased segmental skin sensitivity. Additionally, it has been reported that cyclic jaw muscle activity modulated jaw reflex response to painful and nonpainful stimuli in a phase and modality-dependent way.[35,36] It was assumed, therefore, that jaw clenching might also affect pain-evoked responses in the face, but this assumption was not supported by the present findings. Based on the results of this study, it appears that the modulation created by rhythmic jaw muscle activity on the jaw reflex responses to painful stimuli is primarily associated with modulation of motor activity[1,2] rather than on attenuation of pain perception mechanisms.

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