Pain Sensitivity and Obesity

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Abstract. Endogenous opiates have been implicated as regulators of mood and pain. Recent literature suggests a relationship between these internal opiates and ingestive behaviors in both animals and humans. The present study investigates this relationship by comparing the pain sensitivities of obese and nonobese subjects. Twenty-six subjects (18 females, 8 males) whose weight was 130% or greater of their ideal body weight (IBW) constituted the obese experimental group, while 34 subjects (14 females, 20 males) whose weight was less than 130% IBW formed the nonobese control group. Volunteer subjects were sought from a general medicine clinic of a hospital. Each subject placed his index finger in a pressure device bearing a 3-pound weight and was instructed to report the first occurrence of pain and the desire to remove the finger from the device. Obese subjects were significantly more pain sensitive. The difference in pain sensitivities supports the hypothesis that the weight difference between the obese and nonobese subjects may be related to endogenous opiate control of ingestive behaviors.

Key Words. Obesity, pain, endogenous opiates.

Recent evidence implicates a role for endorphins in eating behavior. Margules et al. (1978) have demonstrated that genetically obese mice (ob/ob) and rats (fa/fa) reduced their food intake when injected with naloxone, an opiate antagonist. Elevated concentrations of naturally occurring β-endorphin were found in the pituitaries of the mice and in the blood plasma of the rats (Margules et al., 1978). Morley and Levine (1980) reported that eating behavior in rats induced by tail pinching is inhibited by naloxone. Lowy et al. (1980) also found naloxone to reduce stress-induced eating in rats. Injection of β-endorphin in the ventromedial hypothalamus of rats produced an increase in eating (Grandison and Guidotti, 1977). Food intake has also been shown to be suppressed by naloxone in food-deprived animals (Brown and Holtzman, 1979; Frenk and Rogers, 1979). Gambert et al. (1980) found a decrease in hypothalamic β-endorphin in rats who fasted for 2-3 days. Morphine, an opiate agonist, produced a decrease in eating in food-deprived rats and an increase in food consumption in nondeprived rats (Sanger and McCarthy, 1980).

In addition to these animal studies, there are several studies in humans that suggest a possible role for endorphins in eating behavior. In a study conducted by Kyriakides et al. (1980) three patients with Prader-Willi syndrome—a condition characterized by hyperphagia, obesity, hypogonadism (decreased production of sex hormones), and...
low intelligence—were treated with 0.8 and 1.6 mg doses of naloxone. Two of the three persons treated experienced a decrease in eating. In another case a 13-year-old male was afflicted with a hypothalamic dysfunction resulting in abnormal control of temperature, appetite, thirst, pain, and mood; treatment with naloxone reversed the condition in general and the opiate system was cited as a probable etiology for the disorder (Dunger et al., 1980). Sternbach et al. (1982) demonstrated that naltrexone, when administered to four patients as part of treatment for drug rehabilitation, resulted in significant appetite and weight loss.

For biochemical clarity, the endorphins can be divided into two systems: (1) the enkephalins and (2) β-endorphin (Terenius, 1979; Watson et al., 1979). The enkephalins are responsible for short-term analgesia characteristic of the paleospinothalamic pathway (Snyder, 1977). Administration of β-endorphin produces long-term analgesia. Animal studies have found β-endorphin to be a more potent analgesic than morphine (Loh et al., 1976; Tseng et al., 1976; Hosobuchi and Li, 1979). Intraventricular administration of human β-endorphin resulted in analgesic effects accompanied by long periods of relief in patients suffering from clinical pain (Catlin et al., 1979; Hosobuchi and Li, 1979). Other human experiments have shown acupuncture analgesia to be reversible by naloxone, an opiate antagonist (Mayer et al., 1976).

If the weight differences between obese and nonobese humans result, at least in part, from opiate control, then a difference in pain sensitivity should exist between the two groups. The subsequent experiment, then, is designed to examine the hypothesis that obese and nonobese humans have different pain sensitivities. The affirmation of such a hypothesis would implicate an underlying regulation exerted by the human opiate system. Since the reversal of opiate activity (naloxone administration) decreases eating behavior, it might be proposed that high opiate activity is related to increased eating behavior. Thus, obese subjects might be expected to be less sensitive to pain.

**Methods**

**Subjects.** Thirty-two females (mean age = 43.78; SD = 11.22) and 28 males (mean age = 42.92; SD = 14.67) participated in the present experiment. Subjects were sought from the waiting area of a General Medicine Clinic at a large hospital. Subjects, whether patients or visitors, were selected on the basis of availability of time and willingness to volunteer. No one younger than 20 years of age and older than 67 served as a subject. Four persons (three females, one male) declined to participate in the study.

Subjects whose weight represented 130% and greater of their ideal body weight (IBW) were assigned to the obese group. Those subjects whose weight was less than 130% IBW comprised the nonobese control group. IBW comparisons were based on standard height-weight ratio tables compiled by the Metropolitan Life Insurance Company and distributed by the Rhode Island Department of Health. Eighteen females (mean age = 45.00; SD = 11.06) and eight males (mean age = 46.12; SD = 10.99) served as obese subjects. Fourteen females (mean age = 42.12; SD = 11.62) and 20 males (mean age = 41.65; SD = 15.98) were the nonobese controls.

**Apparatus.** A pressure device was used to provide a constant and equal pressure of 3 pounds. The apparatus consists of four main components: a 16 × 5 × 2 inch base, an 8 × 5 × 2 inch 2-pound movable block which suspends perpendicularly to the base, a 1-pound metal weight which rests on the 2-pound block, and an 1/8 inch wide plexiglas edge inserted at the base of the 2-pound block. The device is operated by resting the plexiglas edge (which bears the total 3-pound weight) directly on the desired location of the index finger. This device has been shown...
to be sensitive to naloxone effects in humans (Haier et al., 1981). A standard stopwatch was used to record time measurement in seconds.

**Procedure.** The experimenter marked the first joint from the tip of the index finger of the dominant hand and rested the plexiglas edge on that mark. At the start of the trial, a stopwatch was activated. Time recordings (seconds) were marked for the time the subject first reported pain (threshold) and the entire duration of the trial (total). No subject was allowed to leave his finger in the device for more than 180 seconds. Those subjects who reported no pain or who did not ask to remove the finger after the 3-minute limit were given times of 180 seconds.

After the first trial, the subject was asked to wait approximately 10 minutes and repeat the same procedure. During that interval, the experimenter casually conversed with the subject and asked for the subject's age, height, and weight. Weights of patients were verified by nurse's recordings on the patient's chart. Visitors were weighed by the experimenter during the interval.

The second trial, which was conducted to compensate for any ambiguity in instructions, learning effects, or anxiety factors, followed the same procedure as trial 1. For analysis, the times of trial 1 and trial 2 were averaged for the threshold and for the total pain sensitivity measures for each subject.

**Results**

Two-tailed t tests were computed to determine if obese subjects have a pain sensitivity different from that of nonobese subjects (Table 1). On the basis of the total number of seconds that the finger is kept in the pressure device, the obese group (mean = 81.88) was more sensitive than the nonobese group (mean = 131.03; t = 3.537, df = 58, p < 0.001). When differentiated by sex, the male obese (mean = 93.25) and nonobese (mean = 144.03) maintain a significant difference in total number of seconds (t = 2.484, df = 26, p < 0.02). While the difference in the pain sensitivities of the female obese and control groups follows the same trend (mean = 76.83 and 112.45, respectively), the results do not achieve statistical significance. However, if the weight criterion for inclusion in the obese group is shifted to exclude mid-weight individuals (obese > 185% IBW; nonobese < 125% IBW), a significant difference is apparent between the female obese and female nonobese (mean = 43.14 and 108.06, respectively; t = 3.037, df = 14, p < 0.01). A similar shift in weight criterion for the male subjects (obese > 150% IBW; nonobese < 125% IBW) maintains the difference between the two groups (mean = 87.90 and 140.03, respectively; t = 2.160, df = 21; p < 0.05). (The weight criteria were determined on the basis of the distribution before the analyses were performed; all p values are two-tailed.)

When the same comparisons are made using the threshold measure (the number of seconds until the subject first reports pain), the same pattern of results (Table 2) exists, although not all are statistically significant. The large standard deviations found in Tables 1 and 2 are not uncommon with the use of the pain device (Haier et al., 1981).

Are the differences between the two groups the results of differences in anxiety or other test situation factors? A significant difference between the groups' trial 1 minus trial 2 measures would suggest that the differences in pain measures were an artifact of anxiety or attitudinal and situational variables. However, t-test analyses of the changes of trial 1 minus trial 2 did not result in any significant differences. Thus, the possibility that intervening variables may have accounted for the observed differences in pain sensitivities is diminished. Moreover, the test-retest correlation of total
Table 1. Pain total measure (seconds) in obese vs. control groups

<table>
<thead>
<tr>
<th>Subjects</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
</tr>
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<tbody>
<tr>
<td>Obese</td>
<td>26</td>
<td>81.88</td>
<td>56.09</td>
</tr>
<tr>
<td>Controls</td>
<td>34</td>
<td>131.03</td>
<td>51.14</td>
</tr>
<tr>
<td>Male obese</td>
<td>8</td>
<td>93.25</td>
<td>57.22</td>
</tr>
<tr>
<td>Male control</td>
<td>20</td>
<td>144.03</td>
<td>43.40</td>
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<tr>
<td>Female obese</td>
<td>18</td>
<td>76.83</td>
<td>56.48</td>
</tr>
<tr>
<td>Female control</td>
<td>14</td>
<td>112.45</td>
<td>57.74</td>
</tr>
<tr>
<td>Female obese (&gt; 185% IBW)</td>
<td>7</td>
<td>43.14</td>
<td>15.53</td>
</tr>
<tr>
<td>Female control (&lt; 125% IBW)</td>
<td>9</td>
<td>108.06</td>
<td>54.47</td>
</tr>
<tr>
<td>Male obese (&gt; 150% IBW)</td>
<td>5</td>
<td>87.90</td>
<td>48.08</td>
</tr>
<tr>
<td>Male control (&lt; 125% IBW)</td>
<td>18</td>
<td>140.03</td>
<td>44.89</td>
</tr>
</tbody>
</table>

Obese vs. control: \( t = 3.537, df = 58, p < 0.01 \).
Male obese vs. male control: \( t = 2.484, df = 26, p < 0.02 \).
Female obese vs. female control: \( t = 1.795, df = 30, \) NS.
Females: > 185% vs. < 125% IBW: \( t = 3.037, df = 14, p < 0.01 \).
Males: > 150% vs. < 125% IBW: \( t = 2.160, df = 21, p < 0.05 \).

The number of seconds between trial 1 and trial 2 is 0.794 for all subjects (\( n = 60, p < 0.001 \)), 0.827 for obese (\( n = 26, p < 0.001 \)), and 0.710 for controls (\( n = 34, p < 0.001 \)).

Discussion

These results are consistent with the idea that obesity and the endogenous opiate system are related. However, contrary to initial expectations, obese subjects were more pain sensitive, not less. Furthermore, although the results of animal studies suggested that naloxone would have some effect on obese humans, such a naloxone effect was not found when tested on five obese humans (O'Brien et al., 1982). Although there is no one explanation for the direction of difference found in the present study and the naloxone insensitivity found by O'Brien et al., examination of Sanger and McCarthy's (1980) model of differential responses to morphine offers a possible interpretation.

Sanger and McCarthy propose that the feeding state of an organism may be associated with varying levels of endogenous opiate activity. Specifically, Sanger and McCarthy hypothesize that food-deprived animals who demonstrate no increase in eating after morphine injection may be operating under maximal opiate activity. Conversely, freely feeding animals who demonstrate an increase in eating after morphine injection may be functioning under minimal endorphin activity. Naloxone
Table 2. Pain threshold measure (seconds) in obese vs. control groups

<table>
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<tr>
<th>Subjects</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obese</td>
<td>26</td>
<td>59.40</td>
<td>48.15</td>
</tr>
<tr>
<td>Controls</td>
<td>34</td>
<td>95.51</td>
<td>53.36</td>
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<td>Male obese (&gt; 185% IBW)</td>
<td>8</td>
<td>70.93</td>
<td>44.29</td>
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<td>Male control</td>
<td>20</td>
<td>110.67</td>
<td>51.52</td>
</tr>
<tr>
<td>Female obese</td>
<td>18</td>
<td>54.27</td>
<td>50.11</td>
</tr>
<tr>
<td>Female control</td>
<td>14</td>
<td>73.85</td>
<td>50.00</td>
</tr>
<tr>
<td>Female obese (&lt; 125% IBW)</td>
<td>7</td>
<td>24.78</td>
<td>14.67</td>
</tr>
<tr>
<td>Female control (&lt; 125% IBW)</td>
<td>9</td>
<td>62.67</td>
<td>37.28</td>
</tr>
<tr>
<td>Male obese (&gt; 150% IBW)</td>
<td>5</td>
<td>56.60</td>
<td>23.39</td>
</tr>
<tr>
<td>Male control (&lt; 125% IBW)</td>
<td>18</td>
<td>104.97</td>
<td>49.41</td>
</tr>
</tbody>
</table>

Obese vs. control: $t = 2.709, df = 58, p < 0.01$.
Male obese vs. male control: $t = 1.912, df = 26, NS$.
Female obese vs. female control: $t = 1.098, df = 30, NS$.
Females: > 185% vs. < 125% IBW: $t = 2.455, df = 14, p < 0.05$.
Males: > 150% vs. < 125% IBW: $t = 2.029, df = 21, NS$.

injection in these freely feeding animals should therefore have little effect.

A cautious extension of Sanger and McCarthy's interpretation to human obesity would suggest that endorphin activity of humans may also be related to current feeding state. If so, then a group of obese humans unselected for food deprivation could be operating under a low level of endorphin activity which would result in pain sensitivity and an insensitivity to naloxone. Therefore, the relationship between the feeding state of the organism and level of endogenous opiate activity may be a main consideration in determining the exact relationship between endogenous opiate and eating behaviors.

Although the sample size of this study did not lend itself to an investigation of possible subgroups of pain sensitivities among the obese, it is reasonable to propose that certain subgroups of obesity do exist. Perhaps an endorphin-system problem plays the dominant role in a particular subgroup of obese humans. A similar model for anorexia may be proposed in which specific subgroups afflicted with the disorder may be functioning with some endorphin irregularity. In addition, an opiate addiction model may be used to examine the notion that obese people are “addicted” to food. Also of interest is the question of whether obese persons are more responsive to particular forms of external stimuli (Rodin et al., 1977). Such a phenomenon could provide a supplementary interpretation of the differing pain sensitivities found for the obese subjects.
In conclusion, the results of this experiment demonstrate that a difference in pain sensitivity exists between obese and nonobese humans. This difference in pain sensitivity is consistent with the hypothesis that the endogenous opiate system regulates ingestive behaviors, although the exact nature of this relationship is not yet clear.

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References


