

Effects of Bilateral Auricular Acupuncture Stimulation on Body Weight in Healthy Volunteers and Mildly Obese Patients

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We investigated the effects of auricular acupuncture stimulation on non-obese healthy volunteers and mildly obese patients. Subjects ($n = 55$ and 5 , respectively) averaged 34.5 years old, and BMI was 24.3 and less than 27.5 kg/m^2 , respectively. We also studied the effects of single-blind sham treatment in approximately 500 age-, sex-, and BMI-matched subjects. Small ($0.15 \times 2.0 \text{ mm}$) auricular needles were placed intracutaneously into the bilateral cavum conchae identified by having a resistance of less than $100 \text{ k}\Omega/\text{cm}^2$. In the 2-week pretreatment period, in which body weight was measured without auricular acupuncture stimulation, 57.1% of the subjects showed a reduction in body weight. This indicates that charting one's own body weight might itself be a useful method of weight control. In the auricular acupuncture treatment period, 35 healthy subjects of 55 (63.6%) showed a decreased body weight, 11 (20%) showed an increased body weight, and 9 (16.4%) showed no change in body weight. The obese patients showed individual variation, but all achieved weight reduction, with a highly significant correlation between body weight and fat volume. The CT/MRI cross-sectional pictures supported these findings. Sham treatment had no statistically significant effect on body weight. These results suggest that success in achieving weight reduction can be partly attributed to the act of charting of one's own weight pattern. Bilateral auricular acupuncture stimulation can help reduce body weight both in mildly obese patients and in healthy non-obese subjects. In conclusion, this is in accord with the bilateral auricular acupuncture stimulation that it may be useful in the treatment of the obesity. We propose a possible mechanism for the weight-reducing effects of bilateral auricular acupuncture stimulation. *Exp Biol Med* 228:1201–1207, 2003

Key words: auricular acupuncture stimulation; cavum conchae; non-obese healthy volunteers; mildly obese patients; BMI

Auricular acupuncture treatment occasionally produces dramatic body weight reductions in obese patients (1–4), although its physiologic and anorexigenic functions have yet to be explained. Fetal somatotopy and Nogier's inverted somatotopy have been considered, analyzed, and reported by Nogier's French school (5, 6). The similarity between the localization of the motor and somatosensory representations of the ear in the cerebral cortex in the fetus has also been noted in both Western and Chinese journals (3, 7–12).

We have reported the effects of auricular stimulation on feeding-related lateral (LHA) and ventromedial (VMH) hypothalamic neuronal activity in normal and experimental (hypothalamic and dietary) obese rats (13). The following were the results of these animal experiments in normal rats: (i) a neural connection between the auricular region and the feeding-related hypothalamus was revealed, (ii) the existence of an "acupuncture non-effective" group analogous to a morphine non-effective group was shown, (iii) specific responding sites on the sub-surface of the rat auriculae were located, (iv) the fact that the neuronal activity of the LHA as a feeding center is significantly inhibited by electrical auricular stimulation was shown, and (v) the fact that the neuronal activity of the VMH as a satiety center is significantly increased by electrical auricular stimulation was shown. In experimentally obese rats, the results indicated that LHA neuronal activity is inhibited by auricular stimulation in both hypothalamic (VMH-) and dietary obese rats. The effect on VMH neuronal activity of auricular acupuncture stimulation clearly depended on the degree of obesity. The previous animal experiments suggested that rather than reducing appetite, auricular acupuncture stimulation is more likely to be concerned with establishing and preserving a feeding of satiation. We should thus expect auricular acupuncture to be more effective in obese rats than in normal ones.

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A search of the international database for systematic investigations of the effects of auricular acupuncture on body weight in rats (13, 14) and normal subjects and/or obese patients revealed a few studies other than those published by us (11, 15–17).

This study attempted to clarify the influence of bilateral auricular acupuncture stimulation on body weight in healthy, non-obese volunteers and a few mildly obese (BMI > 26) patients. Preliminary results have been reported elsewhere (15).

Materials and Methods

Test Subjects. The subjects were 55 (male 26, female 29) healthy volunteers averaging 34.5 (17–57) years of age, with a BMI [body mass index; body weight (kg) divided by height (m) squared] of 24.3 (19.2–25.7) kg/m² and 5 mildly obese patients [male 2, female 3; average age 31.6 (18–67) years, BMI 26.5 (26–27.7) kg/m²].

Stimulation. Small (0.15 × 2.0 mm) auricular needles (Seirin, Spinex, Tokyo) were inserted intracutaneously into the bilateral cavum conchae, a vagally (Arnold n.) innervated region identified by having a resistance of less than 100 (27.1–76.0) k Ω /cm². The auricular acupuncture needles were left *in situ*, but replaced with new ones once every week.

Measurements of Daily Body Weight Change. Body weight was measured four times a day: immediately after waking in the morning (A.W.), immediately after breakfast (A.B.), immediately after dinner in the evening (A.D.), and immediately before going to bed (B.B.). Measured weight was charted [to illustrate daily weight change (18)] by the subjects themselves throughout the experimental period. The subjects also indicated and checked their appetite on the appetite indicator (scale) (15).

Experimental Period. The phases were: weeks 1 to 2, no stimulation as control period (I-1–I-2); weeks 3 to 8, needles inserted and fixed with tape, with the final set of needles being removed on the last day of week 8 (T1 to T6); weeks 9 to 10, body weight measured (with no stimulation) to observe after-effects (A-1 to A-2). Occasionally, 2 or 6 months later body weight was measured for 7 days (A3). In some mildly obese patients ($n = 3$) a longer-term examination was carried out; this examination involved a 4-week pretreatment phase (I-1 to I-4), an 18-week stimulation phase (T-1 to T-18), and an 8-week post-stimulation phase (A-1 to A-8).

Single-Blind (Age-, Sex- and BMI-Matched) Control Study as a Prior Study. Prior to the study proper, a large group of healthy volunteer subjects (who gave informed consent) was divided into two groups (A and B) for a single-blind examination. There were a total of 501 subjects in group A (female, 262; male 239) and a total of 520 in group B (female, 261; male 259). The subjects were age-, sex-, and BMI-matched with respect to the experimental subjects. The subjects in group A simply measured their body weight for 18 weeks (charting it four times a day at

A.W., A.B., A.D., and B.B.) without any acupuncture-related stimulation or interference with their ears. The subjects in group B measured and charted their body weight four times a day, like group A. The difference was that those in group B received sham treatment as follows: after 2 weeks' body weight-measuring and charting, auricular needles were inserted intracutaneously into the bilateral cavum conchae, once every week, in weeks 3 to 8 and 10 to 15. However, immediately after insertion the needles were removed and the site was covered with tape. The subjects did not know that the needles had been removed, and firmly believed that they were receiving auricular stimulation.

Computed Tomography and Magnetic Resonance Imaging. Before starting the experiments (pre-treatment) and again 10 weeks later (post-treatment), an adipose tissue analysis was carried out using computed tomography (CT; GE: Speed Advantage SG) and/or magnetic resonance imaging (MRI; Philips: GYROSCAN-NT). This enables analysis of the adipose tissue in the body cavities (e.g., abdominal cavity or thoracic cavity) as well as analysis of the subcutaneous fat.

Body Adipose Volume, Body Fluid Volume, and Hematology. Body adipose (fat) volume (kg) or percentage (%), body weight without fat volume(kg), body fluid volume (ml), and also waist-hip ratio (W/H) were measured once a week by Bio-body impedance methods (Tanita TBF102, Tokyo). Occasionally, blood was collected and a general hematological examination, especially lipid-related parameters, was carried out.

Statistical Analysis. The data obtained after waking each day (A.W.), which were the most stable and lowest, were used for statistical analyses by ANOVA with Duncan and/or Ryan multiple comparison methods (13).

Results

Figure 1 shows an example of a daily illustration chart, in this case for an obese patient (subject #211F) who was one of the most successful at losing weight. Figure 2 shows a specimen time-series average record illustrating daily body weight changes in the same patient, whose weight was significantly reduced (by about 5 kg) by 18 weeks with bilateral auricular acupuncture stimulation.

Comparing between Intact Control Group and Sham Treatment Control Group. Before starting the auricular stimulation experiment, we conducted a single-blind study on group A (in which the subjects simply measured and charted their body weight four times a day for 18 weeks without any auricular-related treatment) and group B (the sham treatment group; see "Methods" section). The average values for initial body weight were 68.9 ± 0.7 (mean \pm SEM, $n = 501$) and 69.2 ± 1.0 ($n = 520$) kg, respectively, no significant ($P = 0.865$) difference being found between the two groups. The average values for final body weight were 67.0 ± 0.6 ($n = 474$) and 67.3 ± 0.6 ($n = 498$) kg, respectively (not significant between groups: $P = 0.734$). In the female subjects, the average values for

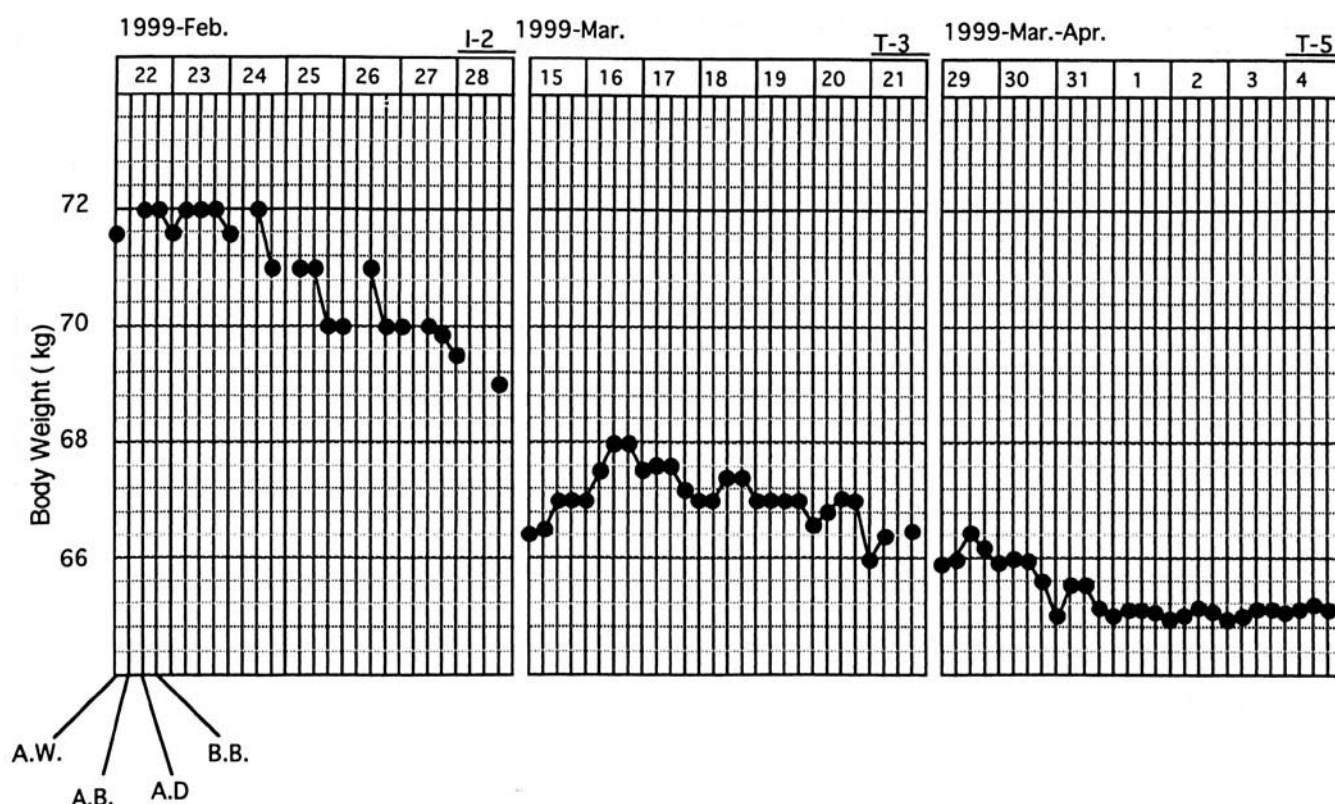


Figure 1. A specimen chart of daily weight pattern (Mildly Obese Patient sb#211): female, 25 years old; BMI at the first consultation time, 25.4 kg/m². It shows a typical case of success in long-term maintenance of weight reduction. Note that weight rebound was not observed over a follow-up period of more than 2 years. Body weight was measured four times a day: A.W., immediately after waking on the morning. A.B., immediately after breakfast; A.D., immediately after dinner, B.B., immediately before going to bed. Ordinate: body weight (kg). Abscissa: weighing date. (Left panel) I-2, 2 weeks after start of charting. Center panel: T-3, 3 weeks after start of bilateral auricular stimulation. (Right panel) T-5, 5 weeks after start of bilateral auricular stimulation.

final body weights were 58.6 ± 0.6 ($n = 262$) and 58.3 ± 0.6 ($n = 264$) kg, respectively (no significant: $P = 0.741$). In the male subjects, the average final body weights were 76.06 ± 0.68 ($n = 239$) and 76.43 ± 0.65 ($n = 259$) kg, respectively (no significant: $P = 0.693$). These results indicated that sham treatment had no statistically significant effect on body weight.

Effects of Auricular Acupuncture on Body Weight in Non-Obese Healthy Volunteers. The effects of bilateral auricular acupuncture stimulation on the body weight of 55 healthy non-obese subjects were examined during phases T-1 to T-6, with phases A-1 and A-2 used to test the after-effects, and phases I-1 and I-2 used to provide a non-treated control period.

In the period of phase T-1 to T-6, body weight showed a significant ($P < 0.01$) decrease in 30 of 55 subjects (54.5%), but it increased in 12 (21.8%), and did not change in 13 (23.6%). In the post-stimulation period of A-1 to A-2, 35 (63.6%) showed a decrease, 11 (20%) an increase, and 9 (16.4%) no change. Thus, bilateral auricular acupuncture stimulation in healthy non-obese subjects was accompanied by a reduction in body weight in more than 50% of the group, while 20% showed a body weight gain.

In those subjects (30 or 35 of 55) who showed a significant reduction in weight on bilateral auricular acupuncture

stimulation, body weight in control phases I-1 to I-2 was 63.8 ± 3.58 (48.8–90.5, $n = 55$) kg. The following were the average body weights and decrease in weight (kg) in these subjects in the respective phases: T-1 to T-2: 62.9 ± 3.5 (+0.2 to -1.8; -0.8 ± 0.2) (mean \pm SEM) kg ($n = 30$, $t = 4.669$, $P = 0.005$); T-3 to T-4: 61.9 ± 3.6 (+0.1 to 10.3; -1.9 ± 0.8 kg ($n = 30$, $t = 3.552$, $P = 0.004$); T-5 to T-6: 62.2 ± 3.4 (-0.4 to -4.1; -1.5 ± 0.3) kg ($n = 30$, $t = 4.649$, $P = 0.0006$). In phases A-1 and A-2, the average body weight was 62.3 ± 5.3 (-0.2 to -4.1, -1.5 ± 0.3) kg ($n = 35$, $t = 4.59$, $P = 0.005$ vs I-1 to I-2).

These results indicate that bilateral auricular acupuncture stimulation can produce a lasting reduction (8–10 weeks) in body weight in healthy non-obese subjects.

Effects of Auricular Acupuncture on Body Fat in Non-Obese Healthy Volunteers. The correlations for body weight versus fat volume and body weight versus W/H were significant ($P < 0.01$), with a high correlation coefficient in each case (body weight versus fat volume, body weight versus W/H) of $r = 0.75$ and $r = 0.90$, respectively. These results strongly suggest that the body weight reduction effects of auricular acupuncture may be caused mainly by a decrease either in fat volume or in adipose tissue, with a resulting decrease in W/H.

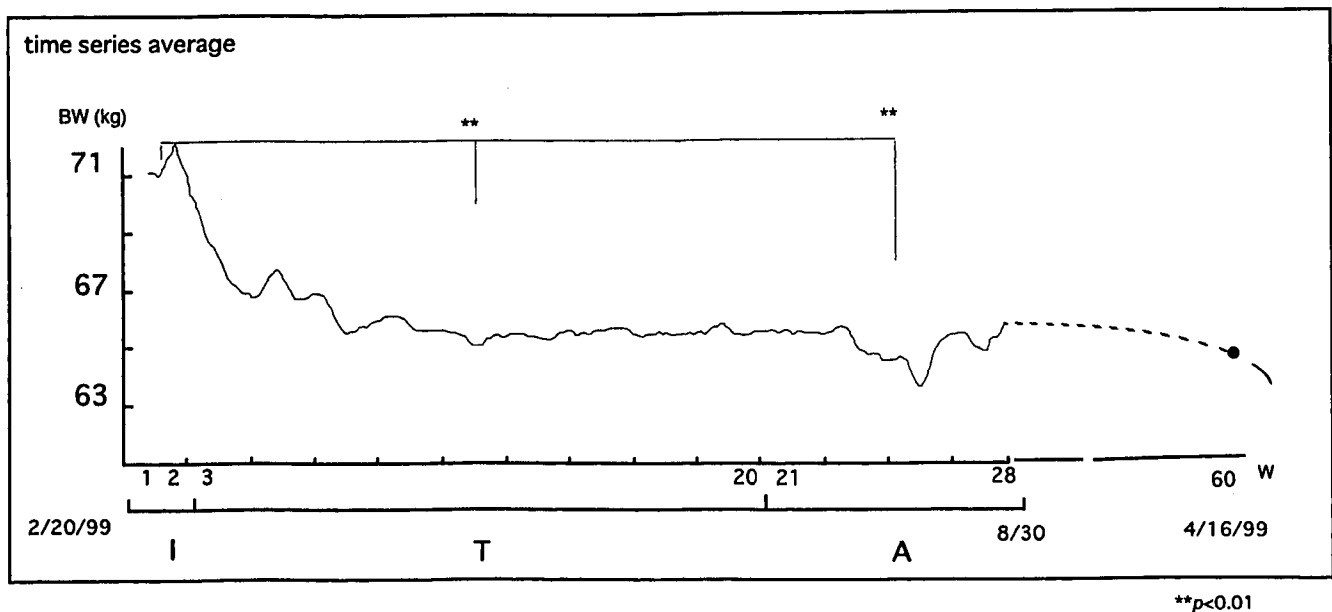


Figure 2. A specimen time-series average plot showing daily body weight change due to an 18-week (T-1 to T-18) course of bilateral auricular acupuncture in a mildly obese patient (sb#211, female 25 years old, BMI 25.4 kg/m²). This subject's body-weight chart is shown in Figure 1. Her body weight was significantly ($P < 0.01$) reduced after bilateral intracutaneous auricle stimulation compared with its value in the pretreatment phases (I-1, I-2). This significant reduction in body weight persisted in to the next phase (A-1 to A-8) after the auricular needles had been removed. Weight rebound was not observed over a follow-up period of more than 2 years.

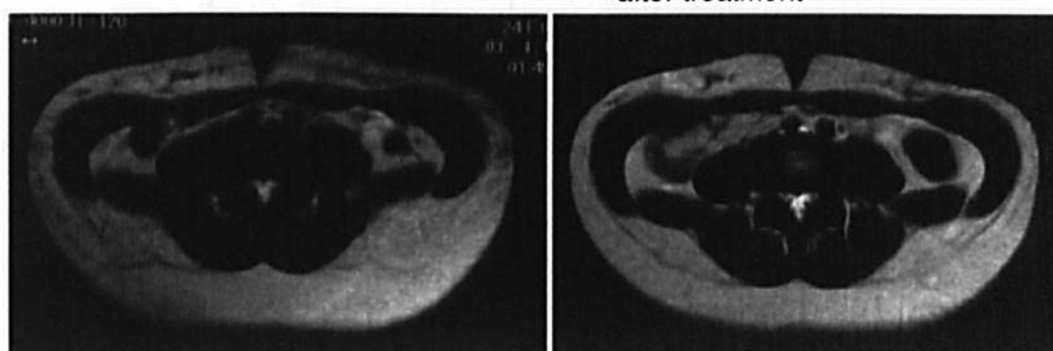
Effects of Auricular Acupuncture on Body Weight in Mildly Obese Patients. The effects of bilateral auricular acupuncture stimulation on body weight in the mildly obese patients ($n = 5$, BMI 26.0–27.7 kg/m² at the first consultation time) were examined during phases T-1 to T-8, with phases A-1 and A-2 to test the after-effects, and phases I-1 and I-2 as a pretreatment control phases. A longer-term examination involving 18 weeks' stimulation was also carried out (see "Methods" section). Typical specimen records charting the daily weight pattern and a long-term time-series average of daily body weight changes (18 weeks, T-1 to T-18; mildly obese patient, sb#211, female, 25 years old, BMI 25.7 kg/m² at the first consultation time) can be seen in Figures 1 and 2, respectively. In this particular case, body weight was significantly reduced after 18 weeks' bilateral intracutaneous auricle stimulation ($P < 0.01$ versus pretreatment phases I-1 and I-2). This significant reduction persisted in to the next phases (A-1 to A-8) after the auricular needles had been removed. Weight rebound was not observed during a follow-up of more than 2 years (body weight after 2 years 64.6 kg; $P < 0.001$ vs 71.8 kg pretreatment value).

The body weight of all such patients was significantly ($t = 4.22$; $P = 0.014$) diminished at the end of 8 weeks' stimulation: the average initial body weight was 71.3 ± 3.2 kg ($n = 5$), and this was reduced by 3.7 kg to 67.6 ± 3.5 kg. Correspondingly, the BMI was significantly decreased ($\Delta 1.72$, 26.5 ± 0.5 to 24.8 ± 0.6 kg/m², $n = 5$, $t = 4.7$, $P = 0.013$).

Effects of Auricular Acupuncture on Body Fat in Mildly Obese Patients. The effects of bilateral auricular acupuncture stimulation on body fat in mildly obese

patients were tested by use of the Bio-body impedance method (see "Methods" section) at the start of the investigation (pretreatment) and the end of experiments (post-treatment). The correlations between body weight (kg) and fat volume (kg) in individual patients were significant in each case ($r = 0.43$ – 0.94 , $P < 0.01$ – 0.0001). Moreover, group average value ($n = 5$) for body weight (kg), fat volume (kg), and percentage of adipose tissue showed significant reductions ($P < 0.014$, $P < 0.00016$, and $P < 0.0011$, respectively) between pretreatment phases (I-1 to I-2) and the final measurement (post-treatment).

Fat volume (kg) and adipose tissue (%) each showed a highly significant reduction after bilateral auricular acupuncture treatment in mildly obese patients. These changes were accompanied by a body weight reduction, and they were reflected by the change in the waist hip ratio (W/H). The group data (I-1 to I-2 versus T10) were as follows: fat volume (kg) was reduced from 22.4 ± 2.0 (range 18.3 to 28.2) to 17.9 ± 1.7 kg ($n = 5$, $t = 7.623$, and $P = 0.0016$). Adipose tissue (%) was reduced from 31.7 ± 2.6 (23.8–37.4) to $26.4 \pm 2.7\%$ ($n = 5$, $t = 8.355$, and $P = 0.0011$). W/H was reduced from 0.9 ± 0.3 (0.9–1.0) to 0.9 ± 0.3 , 0.8–1.0 ($n = 5$, $t = 9.129$, and $P = 0.0008$). Figure 3 depicts a typical specimen showing a comparison between the pretreatment and 10-week post-treatment situations, and exemplifying the effects of bilateral auricular acupuncture stimulation on MRI, body weight, height, BMI, fat volume and percentage, and size of waist and hip in subject # F211. Note that each parameter (except height) showed a decrease as indicated in parenthesis in the right column. Hematology in all mildly obese patients tended show to an in approxi-



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68.0	B.W. (kg)	65.4 (-2.6)
167.0	height (cm)	167.0 (± 0)
24.4	BMI (kg/m^2)	23.5 (-0.9)
25.0	Fat (kg)	20.5 (-4.5)
36.8	adipose %	31.4 (-5.4)
81.5	waist (cm)	79.0 (-2.5)
96.2	hip (cm)	93.5 (-2.7)

Figure 3. Comparison between before treatment and 10 weeks after treatment showing effects of bilateral auricular acupuncture stimulation on MRI, body weight height BMI, fat volume and percentage, and size of waist and hip in subject # F211 (a typical specimen case). Note that all parameters (except height) were decreased (as indicated in parenthesis in the right column).

mately 10% to 15% decrease in TG and LDL, and an increase in HDL (individual data not shown).

These results indicate the cause of body weight reduction effects of auricular acupuncture in mildly obese patients show that it depends on the decrease of adipocytes and/or adipose tissue in total fat as well as the case of non-obese, healthy volunteers.

Discussion

The literature contains evidence that auricular acupuncture treatment can produce dramatic body weight reductions in obese patients (1, 2, 7-12, 16, 17). However, its physiologic and anorexigenic effects are not well understood. We previously made the first and only report of the effects of auricular stimulation on feeding-related lateral hypothalamic (LHA as feeding center) and ventromedial hypothalamic (VMH as satiety center) neuronal activity in normal and experimental (hypothalamic and dietary) obese rats (13). In that study, LHA neuronal activity was inhibited, and VMH activity was excited. While auricular acupuncture stimulation clearly modulated feeding-related hypothalamic neuronal activity in both normal and experimental (hypothalamic and dietary) obese rats, the effects were highly correlated with the degree of obesity. The results of animal experiments suggest that auricular acupuncture stimulation

rather than reduction of appetite is more likely concerned with establishing and preserving a feeling of satiation. Auricular acupuncture stimulation, therefore, should be more effective in obese patients than in non-obese subjects.

The aim of the present study was to clarify the effects of bilateral auricular acupuncture stimulation by obtaining graphic illustrations of weight patterns, examining body fat volume, adipose tissue (lipid) percentage, W/H, CT/MRI cross-sectional pictures, and hematological data in non-obese healthy volunteer subjects and a few mildly obese patients.

The most notable result obtained in the present study was the observation of body weight reduction during bilateral auricular acupuncture stimulation in both non-obese healthy subjects and mildly obese patients. In particular, in phases T-1 to T-6, approximately 60% of healthy subjects showed a persistent and significant decrease ($P < 0.01$, $n = 55$) in body weight (A.W. measurement point compared to I-1, 2). However, in phases I1-2 (in which body weight was measured without auricular acupuncture stimulation) 57.1% of the non-obese healthy volunteer subjects showed a reduction in body weight. This indicates that charting body weight may itself be a useful means of weight reduction (15). Nevertheless, the results of the single-blind sham treatment study on a large number of age-, sex-, and BMI-

matched subjects clearly showed that weight-reduction effects were not different between the sham treatment group and the intact group (who simply measured and charted their body weight). Thus, sham treatment had no significant effect on body weight in this study. We felt that making a comparison between phases II-2 and T1-n or A1-n was a reasonable way to assess the effects of bilateral auricular stimulation on both non-obese healthy volunteer subjects and a few mildly obese patients. In this study, all the mildly obese patients showed marked reductions in body weight. So, what mechanisms might body weight reduction induced by bilateral auricular acupuncture stimulation conceivable? The effect on fat volume clearly corresponded to the effect on body weight (i.e., fat volume, adipose tissue content (%), and W/H were very significantly decreased). The MRI/CT cross-sectional pictures supported these results. So, put simply, the body weight reduction induced by auricular acupuncture may have been due to an enhancement of the lipid metabolism.

Interestingly, although the effects of bilateral auricular acupuncture effects on body weight continued after the stimulation (treatment) period (e.g., A-1 and A-2), its effects on appetite, which were measured by the subjects themselves using an appetite-indicator scale, did not persist in to the post-treatment phase (data not shown). This phenomenon might imply that, in this study, auricular acupuncture stimulation had little or no effect psychologically or emotionally, but instead had a strong effect on body weight physically and somatically, in other words, physiologically. This is not consistent with our previous conclusion in rats about the effect of auricular acupuncture on satiety (see previous discussion) (14). This may indicate a species difference or it may be a reflection of the way the experiments were conducted.

The details of the mechanisms underlying the body weight reduction induced by bilateral auricular acupuncture stimulation remain to be elucidated. A tentatively proposed scheme is shown in Figure 4. It assumes that auricle needles are intracutaneously inserted into the bilateral cavum conchae. This is a site innervated by the auricular vagal nerve (Arnold nerve), and correct placement was indicated by electrically low resistance. In this scheme, impulse gave to white adipose tissue, which expresses OB-protein, leptin, as a satiety feedback hormone. Leptin excites GRNs in the VMH (satiety center) and also inhibits GSNs in the LHA (hunger center) (19, 20). Meanwhile, the synthesis and production of orexins [hunger substances produced only by LHA neurons (21)] and neuropeptide-Y (NPY), in the hypothalamic arcuate nucleus, are decreased or blocked by satiety signals. This would cause feeding to be stopped or decreased (i.e., feeding behavior might be suppressed). In both the short and long term, lipid metabolism might be enhanced, resulting in hypo- or normo-glycemia, and normolipemia, and a resultant decline in body weight.

In conclusion, the results of the present study suggest that success in achieving and maintaining weight reduction

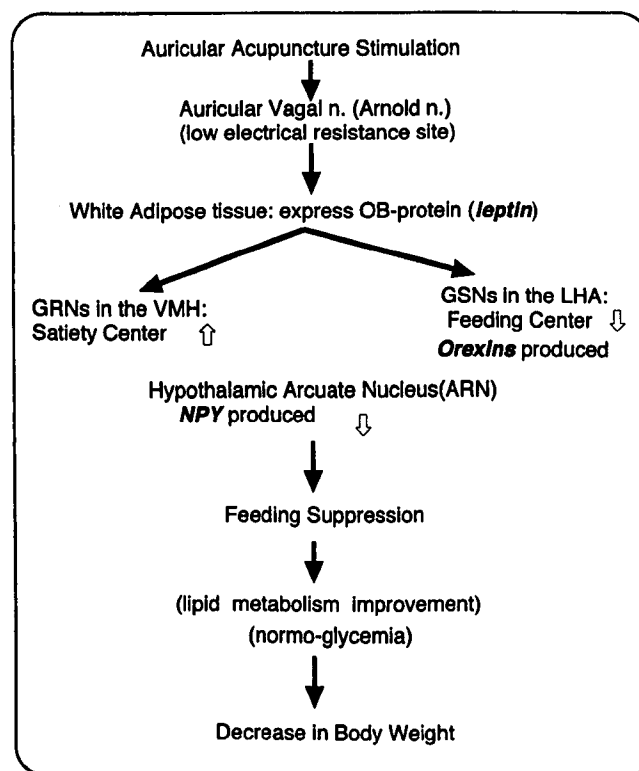


Figure 4. A tentative scheme to explain the effects of bilateral auricular acupuncture stimulation on body weight and lipid metabolism. (↑) excitation. (↓) inhibition.

can be attributed to some extent to keeping a graphic record of one's own weight pattern. Bilateral auricular acupuncture stimulation (treatment) can also reduce body weight by enhancing lipid metabolism in both healthy non-obese subjects and mildly obese patients. This is consistent with the previous suggestion that such treatment might be effective in managing obesity.

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