Taste and weight: is there a link?1–4

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ABSTRACT
Investigations of the relations between taste perception and obesity have concentrated largely on sweet and bitter tastes, with little work on the “savory” tastes—salt and glutamate—and very little work on sour taste. This article briefly reviews current understanding of the relations between the ability to taste different tastes (ie, taste thresholds for sweet, bitter, sour, salt, and umami) and body mass. Obese children and adolescents show a disturbance in some tastes, with lower thresholds in sweet and salt taste perception. Observations on relations between sweet taste threshold and obesity are contradictory; literature discrepancies may depend on the techniques used to evaluate taste. Obese women, however, report higher intensities of monosodium glutamate taste perception. Taste thresholds have been reported to be raised (bitter and sour), lowered (salt), or unchanged (sweet) in obese adults. Taste perceptual changes (threshold, intensity) in obesity are complex and may be different in obese men and women and in adults and children. Very little is currently known about the relations between savory tastes—salt and umami—and body weight, and these areas merit further study. Am J Clin Nutr 2009;90(suppl):800S–3S.

INTRODUCTION
Taste perception, how this may influence eating behavior and hence body mass, has been extensively studied in attempts to understand factors influencing or leading to obesity. The emphasis of a large number of these studies has been the relations between sweet taste perception and body mass. Bitter taste perception, particularly in relation to 6-n-propylthiouracil (PROP) taster status, has also been extensively studied in relation to obesity. In contrast, little is known of any relations between the perception of savory tastes, such as salt and glutamate (umami), and body mass.

SWEET TASTE, SWEET PREFERENCE, AND BODY MASS
Many studies have looked at taste perception and obesity, with a specific emphasis on sweet taste, and sweet-fat taste in particular (1–6). Elevated desire for sweet diets is seen in populations that are more prone to obesity, such as African Americans (7), but evidence suggesting that either sweet taste perception or sucrose preference is a causal factor in obesity is sparse (8). Recent studies have suggested that obese individuals may not only taste sweet as being less intense than normal-weight individuals, but they also have increased sweet liking (9). However, other work has shown that people with high body mass index (BMI; in kg/m²) report lower pleasantness on eating sweet foods compared with people with lower BMI (10) or no differences in sweet taste perception in different BMI groups (3, 11). These differences between studies may be attributable to differences in the psychophysical techniques used to measure sweet taste perception (9). Relations between body mass and sucrose taste perception have been previously reported when sweet foods are associated with fat content. Thus, obesity has been associated with diets containing high levels of both fat and sucrose (12, 13). Fat preference may have a greater influence on body mass than does sweet perception or preference, eg, obese women preferred foods that were less sweet but higher in fat when compared with normal-weight women (1). Sweet and fat preferences are linked in obese people (1), and the pleasurable response to fat, which is greater in obese people (9), is enhanced when the fat is also sweet (14).

Very few studies have examined possible relations between taste threshold and body weight, because most have concentrated on intensity and hedonic ratings of sucrose solutions, or sweet foods (9), for the reason that perceptual measures such as intensity and liking are more likely to drive liking and consumption. Taste thresholds rather than taste intensity or liking measures are less representative of the usual experience of taste, because humans mostly live in a suprathreshold taste world (15). Only a few studies have shown associations between taste thresholds and weight (13, 16), but sucrose thresholds (17) and odor and electrogustometric thresholds (18) were reported as being significantly lower in morbidly obese children and adolescents. In adults, however, no difference in sweet taste threshold or sweet taste hedonics was found in obese females (2, 4), irrespective of the date of onset of obesity. It is unclear whether, and if so how, the enhanced hedonistic response to sweet-fat foods may be related to altered taste threshold in obesity and how changes in thresholds and hedonic responses might be related to...

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food intake, although some reports suggest that loss of taste can directly lead to weight loss (19).

**AVERSIVE TASTES, BITTER AND SOUR, AND BODY MASS**

Taste acuity (threshold), particularly for sour and bitter tastes, has been reported to be related to eating behaviors such as food liking and food neophobia in obese adolescents (16). Taste perception was reported as significantly reduced in subjects with BMI ≥28, only for bitter and sour tastes (13) and not for sweet and salty tastes. A large body of work has investigated the relations between taster status for PROP, a compound that tastes bitter to some individuals (tasters) and not to others (nontasters), eating behavior, and body mass. It has been hypothesized for some time that PROP taster status may be predictive of food preference and eating behavior. Some studies have reported altered food intake in tasters, in that tasters have lower intake of and disliked more foods (20). In children, those who are less sensitive to PROP had lower sucrose preferences than more sensitive tasters and exhibited some dietary differences (21), and PROP taster status was associated with food neophobia and, negatively, with liking of fruit, vegetables, and spicy foods (16).

Literature data on relations between PROP taster status and BMI are contradictory. There are more published data on these relations in women, but there are studies that show either no relation between BMI and taster status (22–25) or a robust relation in which higher BMI is found in PROP nontasters, and supertasters have lower BMI (26–29). It has been hypothesized that the differences between studies may be attributable to other factors that affect eating behavior and BMI, such as dietary restraint (28). In children, in whom such influences might be hypothesized to be less profound, the literature is, however, also unclear. In young children BMI was reported to be higher in tasters (30), to be higher in male nontasters (31), or to show no difference (32, 33).

**SAVORY TASTES, SALT AND GLUTAMATE, AND BODY MASS**

Very little work to date has studied the savory tastes, salt and glutamate (umami), in obesity. Obese children eat significantly

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**FIGURE 1.** Taste perception and BMI. Taste thresholds, liking and pleasantness, were assessed with solutions of salt (NaCl) and monosodium glutamate (MSG) with the use of previously described methods (9, 37, 38). Data for both sexes are presented in the same panel. Statistical comparisons were made within each sex, with ANOVA as stated, other than comparisons between MSG thresholds in normal-weight and overweight men and in normal-weight men and women (Mann-Whitney U tests). A: Mean (±SD) values showing that salt liking was altered in overweight women and normal-weight men compared with the other groups. Overweight women (n = 14) and normal-weight men (n = 10) liked salt, whereas the other groups (n = 11 overweight men, 24 normal-weight women, 8 obese women) did not (*P < 0.05 compared with normal-weight women, ANOVA + Dunnett’s test). B: MSG intensity ratings were positively correlated with BMI in women (P = 0.046, r = 0.3; n = 46). C: Mean (±SD) MSG intensity ratings were significantly higher in normal-weight men and obese women (*P < 0.05 compared with overweight men and normal-weight women; 1P < 0.05 compared with other female groups; ANOVA + Dunnett’s test). D: Mean (±SD) MSG thresholds were significantly higher in normal-weight men (n = 10) than in overweight men (n = 11; Mann-Whitney U test) and were not different in women with different BMI values.
more savory snacks than sweet snacks and more savory snacks than normal-weight children (34), supporting the hypothesis that savory taste perception may be important in body weight and eating behavior. Obese adults also take in more dietary energy in food they classed as salty (35), suggesting that altered salt sensitivity or liking or both may also affect eating behavior. BMI was recently reported to correlate with reported liking for salt-and-fatty food (36), and salt thresholds were also reported as being lower in obese adolescents and children (17). Our findings in a cohort of 69 men and women, with a BMI range of 18.6–36.3 and the use of sodium chloride and monosodium glutamate (MSG) solutions to measure recognition thresholds (38), intensity, and liking [with the use of 1-mol/L solutions and generalized-labeled magnitude scales (9, 37)] suggest that overweight women like salt taste more than normal-weight or obese women, but that the converse is true for overweight men (Figure 1A).

To date, no published data are available on possible relations between glutamate (umami) taste, BMI, and diet. A greater ability to taste MSG was associated with a greater protein liking ability to taste MSG was associated with a greater protein liking (39) in healthy adults, but the subjects were not stratified by weight or BMI. Our work in this area suggests that MSG taste perception may also relate to body weight. Although no differences were observed in MSG liking in different BMI groups, MSG intensity was very weakly but significantly correlated with BMI in women ($P = 0.046$, $r = 0.3$; Figure 1B) but not in men ($P = 0.6$, $r = -0.16$), and this was reflected in the observation that obese women had slightly but significantly increased MSG intensity measures than did normal-weight or overweight women. Normal-weight men had consistently different taste perception than did overweight men and normal-weight women (Figure 1, C and D). Although MSG thresholds were higher in normal-weight men than other groups (Figure 1D), perceived intensity was also higher. The findings for women were less consistent; obese women perceived MSG as more intense than did normal-weight and overweight women (Figure 1C), but otherwise no clear differences were observed in taste perception. None of the differences in taste perception could be attributable to the age of the subjects. The interpretation of these data with respect to taste perception and obesity is not obvious. For men, reduced taste threshold in overweight men might lead to enhanced detection of lower MSG concentrations in food, even though intensity of suprathreshold MSG would not be greater. In obese women, when MSG thresholds are not altered but intensity is increased, it is possible to speculate that in those women that like the taste of MSG-glutamate, the enhanced intensity may also contribute to increased intake and liking of savory-salty-fatty foods (35, 36). MSG is known to enhance food palatability; therefore, it is intriguing to speculate whether the possible increased detection or greater intensity or both of MSG perception could be related to overweight or obesity.

CONCLUSIONS

Taste perception is only one factor in the complex cause of obesity, and it may be a relatively minor one. In adults the determination of eating behavior is affected by many varied things, including attitudes to weight or dieting and nutritional information (8). It has been suggested that people with high BMI may have a higher motivation to eat and less motivation to cease eating when they are paying attention to taste (40). This implies that a change in taste perception, which may alter attention to a particular taste, may affect eating behavior in groups with different BMIs. Many studies into sweet and bitter tastes have suggested relations between taste and body mass, although the data are contradictory for sweet taste. Very little is known about relations between the savory tastes, MSG and salt, and eating behavior, and these areas merit further study. (Other articles in this supplement to the Journal include references 41–69.)

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