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RETROSPECTIVE STUDY

Taste sensitivity, nutritional status and metabolic syndrome: Implication in weight loss dietary interventions

Simona Bertoli, Monica Laureati, Alberto Battezzati, Valentina Bergamaschi, Emanuele Cereda, Angela Spadafranca, Laila Vignati, Ella Pagliarini

Simona Bertoli, Alberto Battezzati, Emanuele Cereda, Angela Spadafranca, Laila Vignati, International Center for the Assessment of Nutritional Status, Department of Food, Environmental and Nutritional Sciences, University of Milan, 20133 Milano, Italy

Monica Laureati, Valentina Bergamaschi, Ella Pagliarini, Department of Food, Environmental and Nutritional Sciences, University of Milan, 20133 Milano, Italy

Author contributions: Bertoli S and Pagliarini E contributed to study design; Laureati M, Bergamaschi V, Cereda E, Spadafranca A and Vignati L contributed to data collection; Cereda E contributed to data analyses; Bertoli S, Laureati M, Battezzati A, Cereda E and Pagliarini E contributed to data interpretation; Laureati M and Cereda E contributed to manuscript drafting; Bertoli S, Battezzati A and Pagliarini E contributed to critical revision of the manuscript; all the authors significantly contributed to the work, read and approved the final version of the manuscript.

Correspondence to: Simona Bertoli, MD, PhD, International Center for the Assessment of Nutritional Status, Department of Food, Environmental and Nutritional Sciences, University of Milan, Via Botticelli 21, 20133 Milan, Italy. simona.bertoli@unimi.it

Telephone: +39-02-50316079 Fax: +39-02-50316077

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Abstract

AIM: We investigated the relationship between taste sensitivity, nutritional status and metabolic syndrome and possible implications on weight loss dietary program.

METHODS: Sensitivity for bitter, sweet, salty and sour tastes was assessed by the three-Alternative-Forced-Choice method in 41 overweight (OW), 52 obese (OB) patients and 56 normal-weight matched controls. OW and OB were assessed also for body composition (by impedence), resting energy expenditure (by indirect calorimetry) and presence of metabolic syndrome (MetS) and were prescribed a weight loss diet. Compliance to the weight loss dietary program was defined as adherence to control visits and weight loss ≥ 5% in 3 mo.

RESULTS: Sex and age-adjusted multiple regression models revealed a significant association between body mass index (BMI) and both sour taste ($P < 0.05$) and global taste acuity score (GTAS) ($P < 0.05$), with lower sensitivity with increasing BMI. This trend in sensitivity for sour taste was also confirmed by the model refitted on the OW/OB group while the association with GTAS was marginally significant ($P = 0.06$). MetS+ subjects presented higher thresholds for salty taste when compared to MetS- patients while no significant difference was detected for the other tastes and GTAS. As assessed by multiple regression model, the association between salty taste and MetS appeared to be independent of sex, age and BMI. Patients continuing the program ($n = 37$) did not show any difference in baseline taste sensitivity when compared to drop-outs ($n = 29$). Similarly, no significant difference was detected between patients reporting and not reporting a weight loss ≥ 5% of the initial body weight. No significant difference in taste sensitivity was detected even after dividing patients on the basis of nutritional (OW and OB) or metabolic status (MetS+ and MetS-).

CONCLUSION: There is no cause-effect relationship between overweight and metabolic derangements. Taste thresholds assessment is not useful in predicting the outcome of a diet-induced weight loss program.

Key words: Taste sensitivity; Nutritional status; Obesity; Metabolic syndrome; Weight loss dietary intervention

Core tip: This paper analyzed for the first time the relationship between taste sensitivity, nutritional status and

metabolic syndrome parameters and its effects on the success of weight loss dietary program. We found that taste sensitivity appears related to weight excess and to metabolic syndrome only in the case of salty taste, while there is no implication related to a weight loss program.

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INTRODUCTION

The prevalence of obesity has grown in parallel with the worldwide rise in metabolic syndrome and diabetes becoming a global public health problem that threatens the economies of all nations. Obesity is fuelled by individual factors, nutrition transition and increasingly sedentary lifestyles that lead to excess caloric intake[1]. Among individual factors, taste sensitivity plays an important role in food preferences, choices, and thus consumption[2]. Taste sensitivity can be defined as the minimum concentration at which the subject is able to perceive a specific taste quality, such as sweet, sour, salty and bitter[2]. A growing literature suggested that the ability to taste phenylthiocarbamide/6-n-propylthiouracil (PROP), synthetic compounds identified as major ligands for bitter-taste-receptor genes (TAS2R38), influences dietary behaviour[3,4]. In particular variation in taste sensitivity to bitter has been associated with differences in preferences for and selection of bitter fruits and vegetables, as well as sweet foods, added fats, spicy foods, and alcoholic beverages[5-7]. Past studies failed to show any association between sweet thresholds and nutritional status[8-10], while more recent studies described a difference between overweight and normal-weight subjects[11,12]. In particular, it has been shown that PROP phenotype is related to body mass index (BMI) in females and that sweet (sucrose) as well as salty (sodium chloride) taste sensitivity are lower in young overweight/obese individuals compared with normal weight controls[13]. This suggests that overweight and obese subjects may have a reduced or distorted sensory sensitivity that might increase the desire and ingestion of food, thus leading to excessive energy intake and weight gain[14]. A recent neuroimaging study seems to support this hypothesis showing that gustatory stimulation induced differential fMRI brain activation patterns in obese patients compared to healthy control subjects[15]. Moreover, a possible interaction between tasting profile such as sweet liking or supertasting status with metabolic syndrome has been suggested in adolescence[16] and more recently in the adults[17]. Finally, other investigators have reported that taste sensitivity may be affected by short-term caloric deprivation in both overweight and lean subjects, with lower thresholds of perception in fasted state than in satiated state[18,19]. Thus, it could be suggested an implication for taste sensitivity also in diet-induced weight loss program. However, evidence in regard to this issue is still in lack.

The purposes of the current study were to investigate: (1) the relationship between nutritional status and taste sensitivity; (2) the relationship between metabolic syndrome parameters and taste sensitivity; and (3) to investigate if sensory acuity could predict the outcome of a diet-induced weight loss program.

MATERIALS AND METHODS

The present study was performed in adherence to the principles established by the Declaration of Helsinki, after the protocol was approved by the local Institutional Ethics Committee. Every patient was asked for informed consent before all the assessments were made.

Forty-one overweight (OW; F:M, 34:7) and 52 obese (OB; F:M, 32:20) patients, admitted to the International Center for the Assessment of Nutritional Status (Università degli Studi di Milano, Italy) only for weight and dietetic concern, and 56 healthy normal-weight (F:M, 36:20) volunteers were recruited. Major study inclusion criteria were age < 65 years (range: 18-64), euthyroidism, no diabetes, no alcohol drinking, no diet to lose weight in the last 6 mo, no restrained eating behaviour and absence of well-established dysgeusia. Binge eating disorder was also excluded according to current diagnostic criteria[20]. On the same day, all the patients underwent a full nutritional assessment and taste sensitivity analysis in fasting state.

Nutritional assessment and presence of metabolic syndrome

Nutritional assessment was performed after 8-12 h of fasting and included: (1) Medical history and physical examination, including blood pressure measurement; (2) Anthropometric evaluation by collecting body weight (to the nearest 0.1 kg) and standing height (to the nearest 0.1 cm) through the same calibrated scale provided of a telescopic vertical steel stadiometer (SECA 220; Germany) and kept the patient dressing only underwear. BMI was derived accordingly [weight (kg)/height (m^2)]. Waist circumference was also measured (to the nearest 0.5 cm) at the midpoint between the iliac crest and the last rib[21]; (3) Body composition by a four-polar impedence meter (BIA; Human IM Scan, DS-Medigroup, Milan, Italy). Whole-body resistance was measured on the left side of the body at frequency of 50 kHz (R_{50}) following international guidelines and fat free mass was calculated using the formula for healthy adults proposed by Deurenberg *et al*[22]. Percentage of body fat mass (BF%) was derived accordingly; (4) Resting energy expenditure (REE) assessment by indirect calorimetry (Sensor Medics Vmax-29N; Anaheim, CA). Concentrations of carbon dioxide and oxygen were measured with the ventilated-hood

Table 1 Compounds used to elicit the 4 basic tastes with relevant dilution step and concentration range

Taste	Compound	Dilution step	Concentration range (g/L)
Sweet	Sucrose	3	1.23-100.00
Bitter	Caffeine	0.2 log	0.16-1.00
Salty	Sodium cloride	3.5	0.50-75.00
Sour	Citric acid	3.5	0.33-50.00

technique. Therefore, gas concentrations were used to determine REE with the Weir equation[23]; (5) Venous blood sampling in fasted state for the evaluation of glucose, high density lipoproteins (HDL) and triglycerides; and (6) Dietary recall by the same well trained dietician to evaluate eating behaviour, eating habits and food preferences which were almost taken into account during diet preparation.

Weight loss program was based on hypocaloric balanced diet providing at least the 90% of measured REE. Energy intake was provided for the 55.3% ± 0.6% by carbohydrates (simple carbohydrates < 15%), 23.8% ± 1.7% by lipids (satured fat < 7%) and 20.9% ± 1.7% by protein. Three-five servings of fruit and vegetables were daily advised; the source of protein intake was dependent on the frequencies of consumption of meat (2 times/wk), fish (4 times/wk), legumes (4 times/wk), eggs (1 time/wk), low-fat cheese (1-2 time/wk), low-fat ham (1-2 time/wk). Olive oil is indicated as the main culinary lipid. Dietary cholesterol was lower than 200 mg/die and fibre intake was about 30 g. Follow-up evaluations to check for compliance and weight loss were set after one and three months since the inception of the dietary program. During control visits an expert dietician measured body weight, fat mass and carried out a careful interview focused on the adherence to prescribed diet.

The updated criteria from the International Diabetes Federation[24] were used to define metabolic syndrome (MetS+). That is to say, subjects had to have ≥ 3 of the following: (1) waist circumference > 94 cm in men and >88 cm in women; (2) serum triglyceride ≥ 150 mg/dL; (3) HDL-cholesterol < 40 mg/dL in men and < 50 mg/dL in women; (4) blood pressure ≥ 130/85 mmHg; and (5) fasting plasma glucose level ≥ 100 mg/dL. Participants treated with antihypertensive or triglyceride-lowering medications were considered as hypertensive or hypertriglyceridemic, respectively.

Subjects in the control group were not evaluated for waist circumference, body composition and REE.

Taste sensitivity analysis

Taste sensitivity determination was performed at the sensory laboratory of the Department of Food, Environmental and Nutritional Sciences (DeFENS- Università degli Studi di Milano) designed according to ISO guidelines[25]. Participants were asked not to smoke, eat or drink anything except water before the test.

Recognition taste thresholds were evaluated by means of the three-alternative-forced-choice method[26]. Sucrose, caffeine, sodium chloride and citric acid were used to elicit sweet, bitter, salty and sour tastes, respectively. For each compound, five concentrations were prepared in mineral water. Concentration range of each taste stimulus was chosen on the basis of threshold values reported in the literature[27,28]. Concentration ranges were established in order that the lowest concentration was clearly below and the highest concentration clearly above the level at which subjects are able to detect or recognize the stimulus. A preliminary test was carried out to adjust concentration ranges since in some cases subjects occasionally recognized the lowest concentration or did not recognize the highest concentration of the stimuli. The final ranges of concentration (expressed in g/L) and dilution factors used to elicit the four basic tastes are reported in Table 1. The solutions were prepared the same day of the session and tested at room temperature. For each basic taste participants were presented with 5 triads of samples marked with three-digit numbers. Each triad consisted of one cup containing the stimulus and two cups containing an equal volume of blank (mineral water). The 5 triads proceeded from weaker to progressively stronger concentration, with the position of the cup containing the stimulus randomized over trials and assessors. For each triad, participants were instructed to indicate which sample was different from the other two[26]. If assessors were uncertain, they were instructed to guess (forced choice procedure). At the beginning of each session, and before each triad, the assessors were instructed to rinse their mouth with mineral water. Data were self-recorded by the subjects on paper sheets.

The individual threshold for each sensory stimulus was calculated as the geometric mean of the concentration at which the last miss occurred and the next higher concentration that was correctly recognized[26]. In addition, from the above mentioned threshold values, an individual global taste acuity score (GTAS) was determined, as recently reported by Monneuse *et al*[12]. For every basic taste we divided patients into tertiles according to taste sensitivity threshold data. We attributed the score 3, 2 and 1 to increasing threshold values and the sum of these scores defined the GTAS. Therefore, the higher the GTAS the higher the acuity.

Weight loss program outcomes

Compliance to the program was defined as adherence to control visits and weight loss ≥ 5% in 3 mo.

Statistical analysis

Variables were presented as frequencies or percentages if categorical (sex, smoking and menopause status, metabolic syndrome) and as mean ± SD if continuous (age, BMI, body fat mass, waist, taste thresholds). As preliminary results indicated that data on tastes sensitivity were not normally distributed, values were log-transformed to achieve a near-Gaussian distribution. Categorical variables were compared by χ^2 test and comparison between groups for continuous variables was performed by Student *t*-test

Table 2 Features of the population according to weight status

	Controls (n = 56)	Overweight (n = 41)	Obese (n = 52)	P
Sex (M:F)	20:36	7:34	20:32	0.061
Age (yr)	41.6 ± 12.3	46.9 ± 11.5	45.8 ± 11.6	0.060
Range	24-66	20-64	19-64	
Current smoking (n)	30 (53.6)	22 (53.7)	33 (63.4)	0.511
Menopause (n)	15 (41.7)	16 (47.0)	15 (46.9)	0.404
BMI (kg/m^2)	22.1 ± 1.7	27.9 ± 1.6	34.8 ± 4.6	<0.001
Body fat mass (%)	-	45.6 ± 5.2	47.6 ± 5.1	0.054
Waist (cm)	-	91.5 ± 7.5	106.2 ± 18.2	<0.001
Metabolic syndrome (n)	0 (0)	8 (19.5)	25 (48.1)	0.004
Taste thresholds				
Sweet (log g/L)	0.74 ± 0.44	0.78 ± 0.40	0.85 ± 0.48	0.418
Salty (log g/L)	0.23 ± 0.54	0.13 ± 0.48	0.36 ± 0.58	0.099
Sour (log g/L)	-0.21 ± 0.54	-0.34 ± 0.40	-0.05 ± 0.67	0.105
Bitter (log g/L)	-0.34 ± 0.35	-0.21 ± 0.29	-0.24 ± 0.30	0.151
GTAS	8.0 ± 1.9	8.0 ± 1.6	7.3 ± 2.1	0.132

Data are reported as mean ± SD or counts (%). P values according to χ^2 or parametric tests (ANOVA analysis), where appropriate. GTAS: Global Taste Acuity Score; BMI: Body mass index; M:F: Male:Female.

Table 3 Multiple regression model between taste sentitivity and nutri-metabolic parameters

	Sour	Bitter	Salty	BMI	BF%[1]	Waist[1]	MetS[1]	MetS criteria[1]
Sour	-	-	-	0.20[a]	0.05	0.27[c]	0.21[a]	0.21[a]
Bitter	0.34[f]	-	-	0.14	-0.09	-0.13	0.02	0.03
Salty	0.26[c]	0.23[b]	-	0.10	-0.08	-0.11	0.23[a]	0.19
Sweet	0.24[d]	0.33[f]	0.26[c]	0.15	-0.15	0.10	0.08	-0.01
GTAS	-	-	-	-0.13[a]	-0.15	-0.05	-0.08	-0.11

[1]For BF%, waist circumference, presence of metabolic MetS and the number of MetS criteria correlations refer to overweight/obese patients (n = 93). Values are standardized coefficients adjusted for age and sex, [a]P < 0.05; [b]P < 0.01; [c]P <0.002; [d]P < 0.005; [f]P < 0.001, between BMI and both sour taste and GTAS, with lower sensitivity with increasing BMI. BMI: Body mass index; BF%: Percentage of body fat mass; MetS: Metabolic syndrome; GTAS: Global Taste Acuity Score.

(two-group comparisons) or ANOVA analysis (multiple-group comparisons) followed by post-hoc comparison of means by Tukey's test.

A linear regression model adjusted for sex and age was built to test the independent relationship between: (1) taste sensitivity (dependent variable) and both BMI and MetS (independent variables); and (2) outcomes, namely dropout and successful weight loss (as dependent variables), and taste sensitivity (each taste as independent variable).

Statistical analyses were performed by the SPSS 20.0 statistical package (SPSS for Windows; SPSS Inc., Chicago). Level of significance was established in a two-sided P value < 0.05.

RESULTS

Taste sensitivity according to nutritional status and metabolic syndrome

The features of the population investigated are presented in Table 2. Normal-weight controls, OW and OB patients were matched for age, gender and smoking and hormonal status. A higher prevalence of MetS characterized obese patients when compared to those overweight despite similar BF%. At baseline, no significant difference was detected neither in any of the taste sensitivity nor in GTAS. However, sex and age-adjusted multiple regression models revealed (Table 3) a significant association between BMI and both sour taste and GTAS, with lower sensitivity with increasing BMI. This trend in sensitivity for sour taste was also confirmed by the model refitted on the OW/OB group while the association with GTAS was marginally significant (P = 0.06).

MetS+ subjects presented higher thresholds for salty when compared to MetS- patients while no significant difference was detected for the other tastes and GTAS (unpaired Student t-test; Table 4). As assessed by multiple regression model, the association between salty taste and MetS appeared to be independent of sex, age and BMI.

Interestingly, similar differences in thresholds where found between MetS+ subjects and lean controls (for salty taste, P < 0.05), while sensitivity among lean controls and MetS- patients was almost comparable (data not reported in tables).

Taste sensitivity and outcome

The features of OW/OB group according to outcomes are presented in Table 5. During the follow-up 29 patients (31.2%) did not attend the second visit. However, among the others (n = 64) continuing the program and reaching the end of the study follow-up, only 37 obtained a successful weight loss (≥ 5%). These three outcome groups appeared well matched for all demographic parameters, prevalence of MetS and nutritional features (P > 0.05) with exception of weight loss (P < 0.001). Patients continuing the program did not show any difference in baseline taste sensitivity and GTAS when compared to drop-outs. Similarly, no significant difference was detected between patients reporting and not reporting a weight loss ≥ 5% of the initial body weight. Then, we sought to evaluate whether an effect of BMI and MetS was present in regard with outcome. No difference (P > 0.05 for all multiple group comparisons) was detected between controls and outcome groups, even after dividing patients on the basis of nutritional (OW and OB) or metabolic status (MetS+ and MetS-). Finally, sex, age and BMI-adjusted linear regression models, including program discontinuation or successful weight loss as alternative dependent variables, confirmed that taste thresholds or global taste acuity (alternative independent variables) are not able to predict the outcome of a diet-induced weight loss program.

DISCUSSION

Taste sensitivity may be involved both in the pathogenesis of weight excess, through food choice and energy intake, and in the lack of compliance to a diet-induced weight loss program. These were the issues we investigated in

Table 4 Taste sensitivity in overweight and obese patients according to metabolic syndrome and gender

	Overall			Women			Men		
	MetS+ (*n* = 33)	MetS- (*n* = 60)	P[1]	MetS+ (*n* = 21)	MetS- (*n* = 45)	P[1]	MetS+ (*n* = 12)	MetS- (*n* = 15)	P[1]
BMI (kg/m^2)	33.7 ± 5.2	30.7 ± 4.2	0.002	33.5 ± 4.8	30.0 ± 3.9	0.002	34.1 ± 6.1	32.7 ± 4.4	0.485
BF%	47.7 ± 6.0	46.4 ± 4.7	0.281	50.3 ± 4.4	47.2 ± 4.5	0.013	43.1 ± 5.8	43.8 ± 4.2	0.744
Waist (cm)	106.2 ± 14.2	96.1 ± 16.3	0.004	101.9 ± 11.2	94.1 ± 9.4	0.005	113.9 ± 16.0	102.2 ± 28.0	0.288
Sweet (log g/L)	0.87 ± 0.41	0.80 ± 0.47	0.396	0.81 ± 0.45	0.72 ± 0.43	0.458	0.97 ± 0.31	1.02 ± 0.51	0.730
Salty (log g/L)	0.43 ± 0.56	0.16 ± 0.52	0.029	0.31 ± 0.50	0.10 ± 0.45	0.121	0.65 ± 0.62	0.33 ± 0.67	0.244
Sour (log g/L)	-0.01 ± 0.69	-0.27 ± 0.49	0.069	-0.08 ± 0.59	-0.39 ± 0.39	0.022	0.11 ± 0.85	0.08 ± 0.61	0.859
Bitter (log g/L)	-0.22 ± 0.28	-0.23 ± 0.31	0.956	-0.24 ± 0.27	-0.23 ± 0.29	0.846	-0.18 ± 0.30	-0.23 ± 0.37	0.757
GTAS	7.4 ± 2.0	7.7 ± 1.9	0.440	7.8 ± 2.0	7.8 ± 1.7	0.936	6.8 ± 1.9	7.5 ± 2.4	0.414

P values according to unpaired Student *t*-test or Wilcoxon-Mann-Whitney test. [1]MetS+ *vs* MetS- within the same group (overall or women or men). BMI: Body mass index; BF%: Percentage of body fat mass; MetS: Metabolic syndrome (+, presence; -, absence); GTAS: Global Taste Acuity Score.

Table 5 Features of overweight and obese patients according to the outcome

	Drop-out	Continuing the program		
		Overall	WL < 5%	WL ≥ 5%
	(*n* = 29)	(*n* = 64)	(*n* = 27)	(*n* = 37)
Sex (M:F)	8:21	19:45	6:21	13:24
Age (yr)	45.3 ± 11.4	46.7 ± 11.7	48.1 ± 12.1	45.7 ± 11.4
Current smoking (*n*)	15 (51.7)	40 (62.4)	14 (51.6)	26 (70.2)
Menopause (*n*)	9 (42.9)	22 (48.9)	11 (52.4)	11 (45.8)
BMI (kg/m^2)	31.0 ± 4.3	32.1 ± 5.0	32.8 ± 4.8	31.6 ± 5.2
Body fat mass (%)	46.6 ± 4.9	46.9 ± 5.3	47.8 ± 5.3	46.3 ± 5.4
Waist (cm)	99.3 ± 13.2	99.9 ± 17.5	112.7 ± 12.3	99.7 ± 20.5
Metabolic syndrome (*n*)	10 (34.5)	23 (35.9)	10 (37.0)	13 (35.1)
Weight loss (%)	-	-5.6 ± 3.5	-2.5 ± 1.7	-7.8 ± 2.5
Taste thresholds				
Sweet (log g/L)	0.87 ± 0.35	0.80 ± 0.48	0.79 ± 0.52	0.81 ± 0.46
Salty (log g/L)	0.27 ± 0.49	0.25 ± 0.57	0.23 ± 0.53	0.26 ± 0.61
Sour (log g/L)	-0.25 ± 0.48	-0.15 ± 0.62	-0.24 ± 0.52	-0.08 ± 0.68
Bitter (log g/L)	-0.27 ± 0.31	-0.21 ± 0.29	-0.26 ± 0.28	-0.16 ± 0.29
GTAS	7.6 ± 2.0	7.6 ± 1.9	7.8 ± 1.7	7.4 ± 2.1

Data are reported as mean ± SD or counts (%). No significant differences were detected in ANOVA comparison among drop out, WL < 5% and WL > 5%. GTAS: Global Taste Acuity Score; BMI: Body mass index; M:F: Male: Female; WL: Weight loss.

the present study.

In the present study, we observed that taste thresholds appear related to metabolic disturbances (*e.g.*, MetS) only in the case of salty taste, MetS+ patients having higher threshold values than MetS- patients. Nonetheless, this association appeared independent of overall BMI. This result seems in conflict with the recent findings by Pasquet *et al*[16] who found a female-specific but positive association between taste sensitivity for sweet and salty tastes and the number of obesity-related metabolic disorders in a group of adolescents. This inconsistency may be ascribed to the different approach used to measure taste thresholds and to the fact that, contrary to Pasquet *et al*[16] study, adolescents were not considered in the present experiment. The positive association found between higher threshold for salty taste and Mets probably is dependent, at least partially, on association between higher threshold for salty taste and hypertension as suggested by Rabin *et al*[29]. Indeed, hypertension is a major component of the metabolic syndrome[24]. It should be pointed out that the association between metabolic syndrome and taste acuity still needs to be clarified, especially in adults, as several changes in perception could occur throughout life for example in reason of hormonal and psychological factors.

Concerning the relationship between taste sensitivity and nutritional status (BMI), the present study evidenced an independent effect of BMI on taste sensitivity for sour and global taste acuity. Moreover, obese individuals showed in general a tendency to higher taste thresholds than lean subjects.

Although the association between BMI and taste has been largely investigated, very few data are available on the relation between taste thresholds and body mass index and our findings appear partially in contrast with those already provided. Pasquet *et al*[16] observed that massively obese adolescents have lower thresholds for taste recognition than normal-weight controls. Obrebowski *et al*[30] found that children and adolescents with simple obesity have lowered electrogustometric thresholds. The authors attributed this behavior to obesity-related metabolic disturbances rather than to body mass *per se*. Similarly to our study, Simchen *et al*[11] have recently investigated the association between taste qualities (sweet, sour, bitter and salty) and BMI in a group of adults. They observed an age dependent relationship with respectively lower and higher sensory capabilities in overweight subjects aged < 65 years and ≥ 65 years for sour and bitter tastes. However, despite the investigation by Simchen *et al*[11] has been performed in a larger cohort, the authors have recognized not to have controlled for an important potential confounder such as restrained eating behaviour, a factor that has been considered by us during recruitment. Besides, body composition and fat distribution assessments were helpful to better characterize our subjects nutritional status, as the pathophysiology of metabolic complications is substantially related to overall and compartmental body fatness[24]. Indeed, a prospective study would be the best way to assess their relationship of taste acuity with future overweight/obesity.

It is also interesting to know if partial or total failure to comply with diet is related to sensory capabilities. We reported that, regardless of the presence of obesity-related metabolic derangements, namely MetS, no apparent effect of taste sensitivity on the adherence to a diet-based weight loss program seems to exist. Accordingly, the assessment of taste sensitivity may not assist in predicting the outcome of dieting and may not be useful to the improvement of clinical practice. A possible explanation of our findings is that a 3-mo follow-up is probably a too short period of time to observe differences. One would argue that other factors (*e.g.*, portions size, psychosocial factors) may be involved in the short-term adherence to a weight loss program[31]. We recognize the lack of sensory capabilities reassessment at the end of the follow-up as a study limitation as we cannot exclude a modification of taste acuity during the program itself. Despite conflicting reports are available on this issue[32], it seems likely that acute fasting (14-16-h-long) results in lower sensory thresholds[18,19]. It should be noted that we performed our study postabsorptively (14-16 h after last meal), in physiologic state. Accordingly, it is reasonable to sustain a lack of involvement of taste perception in dietary compliance. However, motivation to comply is generally high in the initial phases and the long-term effect of diet-related restrained eating behaviour on gustatory sensitivity has never been explored. We know only a study by Tepper and Ullrich[33] in which it is reported that in non-dieting subjects the relationship between body weight and sensory capabilities may be masked by dietary restraint.

The relationship between putative changes in taste sensitivity and drop-out is more difficult to explain but we cannot exclude those patients not attending the second visit did so also for organizing reasons. Finally, we cannot exclude a "pathological" regulation of sensory capabilities in satiated state. It would be probably useful to assess taste sensitivities also in this condition.

With this background, it is clear that the relationship between nutritional status and taste sensitivity deserves further investigation also in view of the fact that present data generalizability is limited in view of the method used and the study sample size.

In conclusion, taste sensitivity (sour and global taste acuity) appears related to weight excess with lower sensitivity with increasing BMI and to metabolic syndrome only in the case of salty taste. However, no implication seems to exist in the compliance to a weight loss program. Further studies still needs to be done to clarify the cause-effect association between taste perception and BMI.

COMMENTS

Background

The prevalence of obesity has grown in parallel with the worldwide rise in metabolic syndrome and diabetes becoming a global public health problem that threatens the economies of all nations. Obesity is fuelled by individual factors, nutrition transition and increasingly sedentary lifestyles that lead to excess caloric intake. Among individual factors, taste sensitivity plays an important role in food preferences, choices, and thus consumption. The role of taste thresholds in the physiopathology and the management of overweight and obesity has been not completely clarified and data available are rather contradictory.

Research frontiers

Recently new findings have suggested that overweight and obese subjects may have a reduced or distorted sensory sensitivity that might increase the desire and ingestion of food, thus leading to excessive energy intake and weight gain. Moreover, some investigators have reported that taste sensitivity may be affected by short-term caloric deprivation in both overweight and lean subjects, with lower thresholds of perception in fasted state than in satiated state. However, evidence in regard to this issue is still in lack.

Innovations and breakthroughs

The authors investigated in overweight and obese patients the relationship between taste sensitivity, nutritional status and metabolic syndrome parameters and the possible implications of this relationship on the outcome of weight loss dietary program.

Applications

The authors shown a direct independent relationship between body mass index and metabolic syndrome and the threshold for sour taste. Successful weight-loss appeared unrelated to sensory capabilities.

Terminology

Taste sensitivity can be defined as the minimum concentration at which the subject is able to perceive a specific taste quality, such as sweet, sour, salty and bitter.

Peer review

The authors sought to determine a plausible relationship between taste sensitivity, nutritional status and metabolic syndrome. They evaluated implications for success in weight loss dietary intervention. The methodology is adequate and analysis well carried out. The work leads to the conclusion that taste sensitivity appears in some measure related to weight excess and metabolic derangements.

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