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Association between smell and taste dysfunction and obesity and metabolic syndrome in older adults*

Sebastian S. Dobrow[1], Jamiluddin J. Qazi[1], Spencer C. Payne[1,2], Jose L. Mattos[1,2]

[1] University of Virginia School of Medicine, Charlottesville, VA, USA

[2] Department of Otolaryngology – Head and Neck Surgery, University of Virginia, Charlottesville, VA, USA

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Abstract

Background: Obesity and metabolic syndrome (MS) are prevalent and associated with negative health outcomes in the elderly. There is a need to identify risk factors for these diseases in this population.

Methodology: The 2013-14 National Health and Nutrition Examination Survey was used in this study. Adults ≥60 were categorized into normosmia, hyposmia, anosmia, and combined anosmia + hyposmia using the Pocket Sniff Test. Taste was evaluated using quinine and NaCl solutions. Multivariate logistic regression models were used to characterize associations between smell and taste status and obesity and MS.

Results: In univariate obesity analysis, normosmia, combined anosmia + hyposmia, and 0.32M NaCl taste dysfunction were significant. 0.32M NaCl taste dysfunction remained significant in multivariate analysis. MS was significantly associated with only tongue tip quinine dysfunction in univariate and multivariate analyses.

Conclusions: Salty taste dysfunction was found to be negatively associated with obesity while bitter taste dysfunction was found to be positively associated with MS.

Key words: Smell dysfunction, Taste dysfunction, Obesity, Metabolic syndrome, NHANES

Introduction

Smell and taste dysfunction can have significant effects on quality of life and mortality, especially in older adults [1-3]. In the United States, the prevalence of smell and taste impairment may be as high as 13% and 17%, respectively [4-6]. It has also been shown that this prevalence increases with age [6-8]. Yet, despite the high prevalence and adverse consequences of smell and taste dysfunction, literature characterizing these conditions remains relatively undeveloped.

It is known that food choice and food intake are influenced by smell and taste [9]. As such, it is unsurprising that associations have been found between metabolic diseases, such as type 2 diabetes mellitus, and impaired smell and taste [10-13]. The pathophysiology underlying these associations is complex and an active area of study [10,14]. We investigate both obesity and metabolic syndrome in this study. While these two conditions are likely pathophysiologically related, they are independent diseases and therefore could have different risk factors [10-15,16]. Obesity, defined as a body mass index (BMI) greater than or equal to 30kg/m^2, has reached an unprecedented prevalence in the United States [15,17]. It is estimated that by 2030, up to 86% of adults in the United States will be obese [15]. Obesity is associated with a decrease in life expectancy of up to almost 20 years [15]. For each 5kg/m^2 above a BMI 25kg/m^2, there is an increase in mortality of 30% on average, mostly owing to cardiovascular causes [15]. The etiology of obesity is likely multifactorial, but

overconsumption of nutrient-poor foods is an established risk factor [14,15,18].

In the United States, the number of adults aged 65 years or older is predicted to nearly double by the year 2050 [18]. Additionally, the literature estimates that currently about 40% of adults over 60 years of age in the United States are obese and this will continue to increase [19]. This suggests a substantial portion of the American population will be elderly and obese in the future. In combination with age-related comorbidities, obesity in this population can substantially and negatively impact the health and quality of life [20,21]. In fact, the obesity-related decline in functional status increases risk for falls and other adverse events, as well as increasing the risk of institutionalization [20,21]. Therefore, it is important to be able to identify risk factors for obesity in this unique population.

Since smell and taste influences food preferences, there would seem to be a connection between disorders of smell or taste and obesity. However, despite this intuitive link, the literature regarding the association between smell and taste dysfunction and obesity is sparse and riddled with contradictory results. Some studies have found increased BMI to be associated with olfactory dysfunction; others have found no connection [4,10,22,23]. With regard to taste, increasing BMI has been associated with decreased taste sensitivity in certain studies, while others have linked obesity to increasing sensitivity towards sweet, salty, or fatty tastes [22,23,26,27]. These discrepancies are likely due to methodological inconsistencies between studies. It is also worth noting that very few studies have examined the link between obesity and smell dysfunction (SD) or taste dysfunction (TD) in the elderly, so it is difficult to apply many existing conclusions in the literature to this population.

Metabolic syndrome (MS) is another disease influenced by nutritional choices; the pathology consists of insulin resistance, hypertension, dyslipidemia, and central obesity [15,16]. MS is associated with a 2-fold increase in the risk of coronary heart and cerebrovascular disease, and a 1.5-fold increase in all-cause mortality [15]. An estimated 33% of adults in the United States are estimated to meet the criteria of MS [15,28,29]. This prevalence is estimated to increase with age [30].

In fact, the estimated prevalence of MS in adults over 55 years is 37%, higher than that in the general population [31]. In older adults, MS has been associated with many negative health outcomes, including higher risk of cardiovascular morbidity and mortality, declines in mobility, and poorer quality of life [32-36]. Early identification of older adults at risk for MS could facilitate targeted interventions to mitigate further illness and functional decline.

Despite the high prevalence of this disease, the literature describing MS's association with smell and taste dysfunction is very sparse. One study in 2016 showed an association between smell dysfunction and metabolic syndrome [16]. Another showed worse smell and taste dysfunction was associated with higher total serum cholesterol levels, a component of MS [30]. However, to the best of our knowledge, no study has used a nationally representative, cross-sectional database to examine the association between MS and objective smell and taste dysfunction in older adults.

In this investigation, our objective was to evaluate for independent associations between SD and TD and obesity as well as MS using a nationally representative sample of older adults in the United States.

Materials and methods

The National Center for Health Statistics (NCHS), a part of the Centers for Disease Control and Prevention (CDC), completes the National Health and Nutrition Examination Survey (NHANES) annually. NHANES samples about 5,000 non-institutionalized civilians, located in 15 different counties each year and applies a complex probability sampling algorithm to produce a nationally representative cohort of individuals across the United States [37]. Interviews are conducted in participants homes while examinations and measurements occur in equipped mobile centers, which travel to locations throughout the country. A physician, medical and health technicians, and dietary and health interviewers comprise the study team. Participation is voluntary and recruitment is carried out by letter from the NCHS director as well as coverage by local media. Participation is voluntary, transportation is provided to mobile centers if required and compensation as well as a report of medical findings is provided to each participant [38].

The survey collects comprehensive health information from these participants, including smell and taste data using subjective (self-reported) as well as quantitative testing methods [39]. This data is entirely de-identified and available for public use [37]. In this investigation, the 2013-2014 NHANES data were used to examine the associations between obesity or MS and quantitative SD and TD in adults 60 years of age or older.

NHANES uses the Pocket Smell Test (PST) to evaluate SD. The PST is an 8-question odor identification test where the participant must choose the correct response from a list of 4 smell description options. The odors include strawberry, chocolate, onion, grape, natural gas, smoke, leather, soap (Pocket Smell TestsTM, Sensonics International, Haddon Heights, NJ, USA). Each correct answer is recorded, generating a score between 0 and 8.

With respect to evaluating SD, the PST has shown high test-retest reliability over 2-week intervals [7,8,40]. Cut-off values were chosen for the PST from the literature as sensitive and specific ways to evaluate for SD [5,8]. Participants were labeled as having SD if they had a score of ≤ 5 on the PST. This was divided into hyposmia (score of 4-5) and anosmia (score ≤ 3). Normosmia was a score of > 5 on the PST.

NHANES uses a 5-item taste identification test to evaluate for

Table 1. Unweighted Cohort Characteristics, stratified by smell and taste dysfunction.

Characteristics	Smell Assessment			Taste Assessment				
	Normosmia	Hyposmia + Anosmia	Anosmia	*Quinine Dysfunction	*NaCl 1M Dysfunction	*NaCl 0.32M Dysfunction	*Quinine Tongue Tip Dysfunction	*NaCl Tongue Tip Dysfunction
N (% of total n)	81.20	18.80	4.10	14.60	3.20	10.80	62.60	17.60
Age, mean, years	68.4	71.9	73.7	68.8	70	68.9	69.1	69.5
Sex (% of subgroup)								
Female	55.40	41.40	20.00	50.70	60.60	55.60	51.60	47.80
Race/ethnicity (% of subgroup)								
Mexican American	3.50	3.80	1.30	4.20	4.40	3.70	4.50	3.80
Other Hispanic	1.90	4.10	1.10	3.20	3.80	3.30	2.70	2.20
Non Hispanic White	66.20	74.40	79.80	80.40	81.60	80.60	79.70	79.80
Non Hispanic Black	6.20	11.10	11.60	8.90	7.20	7.20	8.40	9.00
Non Hispanic Asian	2.30	5.50	5.90	1.60	2.90	3.60	3.30	4.10
Other / Multiracial	1.10	1.20	0	1.70	40	1.50	1.40	1.10
Education (% of subgroup)								
Less than high school	13.10	18.80	10.60	18.70	14.80	11.60	15.10	10.90
High school graduate	54.00	59	55.70	49.80	38.40	49.70	52.40	68.10
College graduate	33.00	22.20	33.50	31.40	46.60	38.80	32.50	21.00
Income (% of subgroup)								
<$20,000	14.50	17.00	17.50	15.20	24.70	14.30	15.20	16.30
$20,000 - $44,999	26.80	33.50	26.60	33.90	18.80	30.30	26.70	24.70
$45,000 - $74,999	21.90	17.80	18.20	12.90	21.60	17.10	21.50	24.00
> $75,000	31.30	24.40	35.20	32.30	25.30	32.00	30.80	27.80
unknown	5.50	7.30	27.10	5.50	9.70	6.30	5.70	7.10
Hypertension (% of subgroup)	59.60	67.70	49.80	66.30	62.50	60.20	61.90	60.00
Cardiovascular disease (%)	17.90	81.70	19.20	21.00	29.70	17.00	18.50	21.70
Diabetes (% of subgroup)	18.90	20.90	14.00	19.30	24.70	10.60	18.40	23.20
Stroke (% of subgroup)	5.80	11.10	10.60	7.10	11.90	4.60	8.20	5.50
Smoking (% of subgroup)								
Current	11.20	9.80	6.90	15.70	6.60	13.70	12.00	11.20
Former	39.20	43.00	39.40	44.40	42.80	46.30	39.90	44.30
Heavy alcohol use (% of subgroup)	17.40	23.70	23.00	15.60	18.50	12.10	18.90	21.70
Two or more sinus infections (% of subgroup)	44.50	29.80	20.00	33.20	39.40	35	42.00	37.60
Nasal/facial fracture (% of subgroup)	15.60	21.40	22.40	16.30	9.70	20.80	18.90	16.70
Persistent cold/flu in past year (% of subgroup)	7.60	4.70	3.00	4.70	8.40	6.20	7.00	10.50
Caloric intake >3000kcal/day (% of subgroup)	27.60	32.10	66.40	70.90	70.90	66.00	73.00	69.00

Table 1. Unweighted Cohort Characteristics, stratified by smell and taste dysfunction.

TD. Salty or bitter tastants were dissolved at known concentrations in aqueous solutions and then applied to the participants tongue-tip or whole mouth, in a standardized fashion [41]. Both tongue tip and whole mouth testing was done to assess local

Table 2. Univariate analyses of smell and taste dysfunction versus obesity.

Obesity	Odds Ratio	P value	95% Confidence Interval	
Anosmia + Hyposmia	0.64	0.025*	0.44	0.94
Anosmia	0.58	0.19	0.25	1.34
Hyposmia	0.69	0.075	0.45	1.04
Normosmia	1.56	0.025*	1.07	2.28
1mM Quinine	1.01	0.95	0.63	1.63
1mM NaCl	0.85	0.69	0.36	2.00
0.32M NaCl	0.64	0.023*	0.44	0.93
Tongue-tip Quinine	0.93	0.72	0.63	1.38
Tongue-tip NaCl	0.84	0.28	0.60	1.17

*p < 0.05; NaCl = sodium chloride; M = molar

Table 3. Univariate analyses of smell and taste dysfunction versus metabolic syndrome (MS).

Metabolic Syndrome	Odds Ratio	P value	95% Confidence Interval	
Anosmia + Hyposmia	0.96	0.78	0.71	1.30
Anosmia	0.59	0.11	0.30	1.15
Hyposmia	1.14	0.49	0.78	1.66
Normosmia	1.04	0.78	0.77	1.40
1mM Quinine	1.05	0.86	0.62	1.77
1mM NaCl	0.80	0.60	0.32	1.97
0.32M NaCl	0.78	0.28	0.49	1.24
Tongue-tip Quinine	1.45	0.010*	1.11	1.90
Tongue-tip NaCl	1.22	0.33	0.80	1.87

*p < 0.05; NaCl = sodium chloride; M = molar

taste as well as taste using the entire gustatory apparatus, which includes taste receptors on the anterior and posterior tongue, soft palate and pharynx, among other sites as well [42]. The tastants included whole mouth 1 molar (M) sodium chloride (NaCl), whole mouth 0.32M NaCl, whole mouth 1mM quinine, tongue tip 1M NaCl, and tongue tip 1mM quinine. For tongue tip testing, participants then had to identify the tastant from 5 possible choices (salty, bitter, sour, some other taste, or no taste). For whole mouth testing, the participant was asked to provide a a tastant-specific intensity rating as well as identify the tastant from the same 5 choices [43]. The relationship of each test item with obesity or MS was investigated individually.

Obesity was evaluated by measurement of participants body mass index (BMI). Participant's height and weight were collected by trained health technicians. BMI was then calculated as weight, in kilograms, divided by height, in meters squared. Obesity was defined as a BMI ≥ 30kg/m^2 [15,17].

Participants were categorized as having MS if the following conditions, based on published criteria, were met: blood pressure greater than or equal to 130mmHg systolic and 85mmHg diastolic, waist circumference ≥ 102cm in men or 88cm in women, a fasting blood glucose level ≥ 100mg/dL, a serum triglyceride level ≥ 150mg/dL, and a serum high-density lipoprotein (HDL) level < 40mg/dL in men or 50mg/dL in women [15,16]. Despite the distinct criteria for obesity and MS, many participants met criteria for inclusion in both groups. They were analyzed as part of each group they met criteria for and included in both groups if applicable.

Similarly to BMI, blood pressure was measured by trained health technicians after participants were resting quietly in a seated position for 5 minutes. Triglycerides and HDL were measured using standard laboratory procedures on Roche Modular P and Roche Cobra 6000 chemistry analyzers. Fasting blood glucose was determined by the University of Missouri-Columbia methods and equipment. Refer to NHANES 2013-2014 Laboratory Method Files for comprehensive descriptions of the aforementioned procedures [37].

The NHANES 2013-2014 dataset was interrogated for all participants age 60 or older with complete data in the smell, taste, BMI, and metabolic syndrome testing components. Covariates were also included: age, gender, race, education, annual household income, hypertension, cardiovascular disease, diabetes, stroke, smoking, heavy alcohol use (more than 4 drinks a day), sinus infection in the past year, a problem with a smell in the last year, ever having a facial injury or broken nose, persistent cold or flu in the last year, and caloric intake. These covariates are further described in Table 1. 95% confidence intervals were used to estimate the population prevalence of SD, TD, obesity and MS. Then, logistic regression models were constructed to explore the associations between obesity and SD and TD as well as MS and SD and TD. STATA 14.2 software (www.stata.com, RRID:SCR_012763) was used to conduct all statistical analyses.

Statistical analysis

Initially, exploratory univariate logistic regressions were used to analyze the associations between obesity and SD, obesity and TD, MS and SD, and MS and TD. Then, these same associations were explored with multivariate models. Obesity and MS are associated with a variety of demographic and comorbid medical conditions; therefore, multivariate regressions were required to comprehensively explore these associations. In these multivariate models, we controlled for the aforementioned confounding variables. The outcome was presence of obesity or MS in each model. The predictors were SD or TD. Age was the only continuous covariate. All other covariates, shown in Table 1, were categorical. These models were built in stepwise backward elimination fashion until only statistically significant predictors were left in the model. The Homer-Lemeshow test was performed for

Table 4. Multivariate analyses of 0.32M taste dysfunction versus obesity.

Metabolic Syndrome	Odds Ratio	P value	95% Confidence Interval	
0.32M NaCl	0.27	0.011*	0.11	0.66
Age	0.94	<0.001*	0.91	0.98
Hypertension	0.51	0.021*	0.30	0.87
Smoking	2.47	<0.001*	1.47	4.14
Excessive Alcohol Use	0.55	<0.001*	0.39	0.79
Persistent cold/flu in past year	0.39	0.010*	0.21	0.75

*p < 0.05; NaCl = sodium chloride; M = molar

Table 5. Multivariate analyses of tongue-tip quinine taste dysfunction versus metabolic syndrome.

Metabolic Syndrome	Odds Ratio	P value	95% Confidence Interval	
Tongue-tip Quinine	1.48	0.010*	1.12	1.95
Diabetes	0.59	<0.001*	0.47	0.73

*p < 0.05; NaCl = sodium chloride; M = molar

Table 6. Summary of significant associations found between smell and taste dysfunction and obesity and metabolic syndrome.

Obesity			
	Univariate analysis	Multivariate analysis	Interpretation
Anosmia + Hyposmia	OR 0.64, P = 0.025 (95% CI 0.44-0.94)	-	Neither normosmia nor SD correlated with obesity risk after controlling for covariates
Normosmia	OR 1.56, P = 0.025 (95% CI 1.07-2.28)	-	
0.32 M NaCl TD	OR 0.64, P = 0.023 (95% CI 0.44-0.93)	OR 0.27, P = 0.011 (95% CI 0.11-0.66)	Salty TD was associated with decr risk of obesity (covariates controlled)
Metabolic Syndrome			
	Univariate analysis	**Multivariate analysis**	**Interpretation**
Tongue-tip Quinine TD	OR 1.45, P = 0.010 (95% CI 1.11-1.90)	OR 1.448, P = 0.010 (95% CI 1.12-1.95)	Bitter TD was associated with incr risk of MS (covariates controlled)

Significant (P < 0.05) results aggregated from tables 2-5. SD = smell dysfunction; TD = taste dysfunction.

each multivariate model to ensure goodness of fit. All significant tests had a type I error rate of 0.05 or less.

Results

A total of 1,382 participants had complete obesity, MS, smell, and taste survey data. This corresponds to a weighted population size of 51 million. The demographics of these participants, as well as the prevalence of the various SDs and TDs, are described in Table 1. Combined TD had a prevalence of 24.92% (95% CI: 22.05-28.02). The prevalence of obesity in this population is 38.70% (95% CI: 36.13-41.27). The prevalence of MS is 65.60% (95% CI: 57.60-70.31). Obesity and MS are related entities with definitions that allow for overlap between populations. 30.11% of participants with a full set of data had both obesity and MS, 35.49% MS only, 8.59% obesity only, and 25.81% met criteria for neither obesity, nor MS.

Anosmia + hyposmia was significantly associated with a decreased risk of obesity at the time of data collection in only univariate analysis (OR = 0.64, P = 0.025, CI = 0.44-0.94), see Table 2. Normosmia was significantly associated with an increased risk of obesity at the time of data collection in univariate analysis alone (OR = 1.56, P = 0.025, CI = 1.07-2.28), as seen in Table 2. 0.32M NaCl TD is significantly associated with a decreased risk of obesity at time of data collection in univariate (OR = 0.64, P = 0.023, CI = 0.44-0.93), as well as multivariate (OR = 0.27, P = 0.011, CI = 0.11-0.66) analyses (Table 2 and Table 4).

Tongue-tip quinine TD is the only taste variable significantly associated with MS in both univariate (OR = 1.45, P = 0.010, CI = 1.11-1.90) and multivariate analyses (OR = 1.48, P = 0.010, CI = 1.12-1.95), as shown in Table 3 and Table 5. No SD variable was significantly associated with MS.

Significant results and interpretations are summarized in Table 6.

Discussion

To the best of our knowledge, this study is the first to examine the association between quantitative smell or taste dysfunction and obesity or MS in adults age 60 or older using the NHANES nationally representative dataset. Our nationally representative estimate of obesity prevalence is 38.7% in older adults; literature estimates center around 40% [15,17,19]. Our nationally representative estimate of MS prevalence in older adults is 65.6%. This is nearly twice as high as the literature estimates of both the adult and older adult populations [15,28,31,43]. Based on the World Health Organization, Centers for Disease Control and Prevention, and the literature, prevalence of MS is about 30-40% of the adult population [15,28,43]. The reason for the higher prevalence in our study population is unclear, but it may be due to country-based

differences, as other studies have occurred primarily in continental Europe. Additionally, the prevalence of MS will vary based on the definition used, as well as gender and race proportions in the study sample.

In this study, we found quantitative NaCl TD to be associated with a decreased risk of obesity and quantitative quinine TD to be associated with an increased risk of metabolic syndrome, after controlling for confounding factors. It is interesting to note that poor ability to taste salt, a common seasoning in many foods, decreases the risk of obesity. It is also interesting that poor ability to taste quinine, a bitter taste, increases the risk of metabolic syndrome. This could suggest that individuals with decreased capacity to taste certain flavors may be selecting certain foods that alter their risk of developing obesity or MS. The literature regarding this possible trend is contradictory. Simchen et al. found that individuals of 65 years old or more with a BMI > 27kg/m^2 had a significantly poorer ability to detect sour tastes, an increased ability to detect salty, bitter, and sweet tastes [22]. Hardikar et al. had similar results, showing that obese individuals were more sensitive to salty and sweet flavors, and perceived them as more intense, compared to leaner controls [27]. However, Vignini et al. reported that increasing BMI was associated with a general decrease in detecting salt, sweet, sour and bitter tastes [26]. Sartor et al. showed that obese subjects perceived salty and sweet tastes as less intense [23].

These studies were all limited by small sample sizes and specific study populations. Our results, that salty TD decreases the risk of obesity and bitter TD increases the risk of MS, seem to support the findings of Simchen et al. and Hardikar et al. Taken together, these findings support the hypothesis that capacity for detecting particular tastes may influence food selection and therefore the risk of developing metabolic diseases (e.g. obesity and MS). However, we are only able to measure associations in our analyses and further rigorous study is needed to identify if specific tastes are associated with risk of obesity or MS. This is especially true regarding MS, as only a paucity of literature investigating this topic currently exists. Additionally, these tastants are tested in isolation, and how they influence food choice cannot be determined from our results.

With respect to SD, our univariate analyses suggest that anosmia + hyposmia may decrease the risk of obesity, while individuals with normal smell capacity are at an increased risk of developing this disease. Given the known effect of smell on food consumption, it is possible that SD could lead to food preferences that are protective against metabolic disease. In fact, Rasmussen et al. found that individuals with diabetes and SD consumed fewer total calories per day compared to diabetics without SD [10]. However, our univariate SD results are not supported in our multivariate obesity models and therefore we can make no conclusions based on our results.

The current literature regarding the association between obesity and SD is contradictory. Richardson et al. found that quantitative SD was more prevalent in morbidly obese individuals compared to moderately-obese controls [24]. However, Simchen et al. showed that quantitative SD was less prevalent in obese individuals, compared to non-obese controls, if they were age 65 years or more [22]. Notably, both of these studies were limited by small sample sizes and non-representative patient populations.

It is worth mentioning that our results stand in direct contrast to Liu et al., who used the 2013-14 NHANES dataset to show that neither obesity (categorical) nor BMI as a continuous variable was associated with quantitative SD or TD in adults 40 years or older [4]. However, these authors defined smell dysfunction as failing to identify 6 or more odors on the 8-item Pocket Smell test and defined taste dysfunction as failure to identify sodium or quinine using both the whole-mouth and tongue-tip solutions for each flavor [4]. It is possible that the stricter definitions of SD and TD used in Liu et al.'s investigation, in addition to the larger age range, were unable to capture the specific associations found in our study. However, since their sample size was larger, it is possible that their results are more robust than ours. Again, more investigations are needed to characterize the link between SD and TD and obesity and MS.

Our paper has several limitations. Firstly, we could only include confounders in our multivariate models that were captured in the NHANES dataset. For example, NHANES does not include a sweet item in its taste identification test. We were therefore unable to specifically evaluate if impaired ability to taste sweet flavors was associated with obesity or MS. We were also unable to control for cognitive dysfunction or neurodegenerative diseases, which can affect the ability to smell and taste [4,9,29].

Another limitation of our study is the lack of gold standard for diagnosing SD and TD. The methods used in NHANES, while quantitative, are concise and must be administered on a population level; therefore, they may not capture the same information as more detailed examinations. These tests also only occur on a single occasion, which may not accurately represent long-term function. Additionally, since the NHANES database is across-sectional survey at a single time-point, we cannot prove causality in our study, only associations.

Conclusion

Smell and taste dysfunction are relatively prevalent among older adults in the United States. Using a nationally representative dataset, we show that quantitative salty TD decreases the risk of obesity in adults age 60 or greater, while quantitative bitter TD increases the risk of metabolic syndrome in the same population. These findings suggest that TDs may be influencing food preferences, leading to altered risk of developing obesity or MS. Further studies are needed to characterize the associations between smell and taste dysfunction and obesity or MS.

Authorship contribution

SSD: Data analysis and interpretation, manuscript preparation and revisions; JJQ: Data collection, data analysis and interpretation, manuscript preparation; SCP: Project conception, manuscript revisions; JLM: Principal Investigator, project conception and design, manuscript revisions.

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Ethics approval and consent to participate

No approval or consent needed as only publicly available data was used.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available in the National Health and Nutrition Examination Survey 2013-2014 repository, https://wwwn.cdc.gov/nchs/nhanes/continuousnhanes/default.aspx?BeginYear=2013.

Conflict of interest

The authors declare that they have no competing interests.

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Jose L. Mattos, MD MPH
University of Virginia School of Medicine
1 Hospital Drive
2nd Fl., OMS, Room 2741
Charlottesville
VA 22903
USA

Tel: +1 (434) 924-5934
E-mail: jm6cb@virginia.edu