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Otitis media exposure associates with dietary preference and adiposity: A community-based observational study of at-risk preschoolers

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ABSTRACT

Chronic exposure to otitis media (OM) has been linked to risk of overweight/obesity. Here we tested if dietary behaviors explained some of the OM–adiposity relationship among 485 racially-diverse, low-income preschoolers (253 girls, mean age = 45 ± 7 months) enrolled in government-supported urban preschool programs. From measured weight/height, 4% were underweight, 17% were overweight and 13% were obese. OM exposure according to parent report varied across nearly equal quartiles—low (never, once) to high (3–5 times, 6 + times) exposure categories. Boys were more likely to be in the high exposure categories. Parents rated their child's liking/disliking of foods (high-fat/added sugar, fruits/juice, vegetables) and non-food activities. In analysis of covariance (ANCOVA), mean liking for vegetables and fruits/juice fell as OM exposure increased, with significant differences between lowest and highest exposure categories ($p<.05$). Food neophobic versus non-neophobic preschoolers also liked vegetables and fruits less ($p<.001$). In a two-way ANCOVA, main effects of OM and food neophobia independently predicted vegetable and fruit liking; preschoolers with more OM exposure and neophobia had the lowest liking. Although ANCOVA failed to reveal OM effects on mean liking for fat/sugar foods, the relative ranking of liking for these foods differed by OM category. Fat/sugar foods were ranked as most preferred for the high OM children, particularly the boys, surpassing the ranking of pleasurable non-food items. Conversely, low OM children ranked pleasurable non-food items and fruits/juice as more pleasurable than high OM children. BMI percentile varied with OM exposure, but not neophobia: preschoolers with the greatest exposure averaged the highest percentiles. In multiple regression analyses, liking for vegetables or fruits failed to associate significantly with BMI percentile. There was a small but significant association between greater fat/sugar liking and higher BMI percentile. Overall these findings confirm associations between high OM exposure and elevated adiposity in preschoolers. They also suggest this relationship is explained through lower affinity for vegetables and fruits and greater affinity for fat/sugar foods.

1. Introduction

Substantial effort is mounting to prevent obesity and associated health risks from developing in children and perpetuating into adulthood. According to the U.S. Centers for Disease Control and Prevention [1], prevalence rates of obesity (Body Mass Index above the 95th percentile) in preschool children (2 to 5 years of age) doubled from 5% in 1976–1980 to 10.4% in 2007–2008 [2]. Low-income minority preschoolers are disproportionately affected by obesity, with obesity rates that exceeded national rates (12.4% in 1998 and 14.6% in 2008) [3]. Diets high in fruits and vegetables but low in total fat and added sugars promote energy balance for obesity prevention and assure attaining essential nutrients for health, according to a critical review that served as the basis of the 2010 Dietary Guidelines [4]. The present study examines the association between exposure to otitis media, a common childhood ailment, preferences for foods and alternative reinforcers (i.e., pleasurable non-food activities), and adiposity. The overall hypothesis for this investigation is that a significant exposure to otitis media may influence the tastes and oral sensations from foods, and thus affect body weight through food liking and dietary selection. Understanding of factors that influence food preferences early in life is critical to promotion of healthy eating throughout life [5] to decrease the risk of diet-related chronic diseases.

Otitis media (OM) involves inflammation and/or infection of the structures of the middle ear, which can occur at any age, but are considerably more common in children [6] with peak incidence from 6 to 18 months of age [7]. From cohort studies, 75% percent of children experience at least one episode of OM [8] with increasing rates among young children [9]. Prevalence of OM is greater among boys than girls [6], bottle versus breastfed infants [10] and children of lower socioeconomic status [10,11].

Exposure to OM is linked with taste and oral sensation through the chorda tympani branch of cranial nerve VII. The chorda tympani nerve (CTN) innervates taste buds within fungiform papillae on the

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anterior two-thirds of the tongue; these papillae are also innervated by the trigeminal nerve. The CTN leaves the anterior tongue and travels through the middle ear where it is vulnerable to damage from infection and inflammation associated with OM. Counterintuitively, damage to (or anesthesia of) the CTN increases taste sensations from other areas of taste nerve innervation [12,13] and increases oral somatosensations (touch, temperature, pain) [14] due to release of inhibition of cranial nerves V, IX and X. Pathology-associated taste damage from the CTN could release inhibition of other sensory nerves that innervate the mouth, increasing taste sensations from taste-related fibers in cranial nerves VII and IV as well as somatosensory input [15]. Preliminary studies on children found reduced bitterness from quinine but enhanced responses to citric acid on the tongue tip in children with chronic OM (citric acid is both a tastant and an irritant) [16]. Interestingly, a recent study found lower electrogustometry thresholds (more sensitive) in children with OM exposure than those without this exposure [17]. Electrogustometry does not reflect chemical taste stimulation (i.e., sweet, sour, bitter, salty sensations) [18], may not detect taste disturbances [19], and could reflect somatosensation that could actually be heightened in those with CTN taste loss [15]. Variation in CTN taste can explain differences in diet and nutrition outcomes in adults; those with lower CTN taste alone or relative to whole mouth functioning report for less preference for and intake of vegetables [20], consume more alcoholic beverages [21] and have greater central adiposity [22] than do adults without this response pattern.

Prior evidence supports the existence of a relationship between OM exposure and body weight and/or dietary behaviors. History of recurrent OM treated with tympanostomy tube treatment was associated with increased risk of being overweight in children up to the age of 2 [23] and children from 2 to 7 years old [24]. In older children, exposure to OM has been linked to overweight risk from a small community-based study [25] and unpublished preliminary data analysis of a nationally-representative longitudinal sample [26], although the relationship was not found in children recruited from an otolaryngology practice [17]. Based on survey responses, adults with greater history of OM also reported greater liking for high-fat foods and were heavier [27]. A pilot study by our team found that children with reported OM history show greater sweet intakes (candy, baked goods, sweetened drinks) and lower vegetable intakes [28].

The goal of the present study was to examine the association between reported exposure to OM, dietary behaviors and body weight among a community-based sample of preschoolers who would have high-risk of OM and obesity. The first aim was to test whether the frequency of OM exposure was related to liking for vegetable, fruits, and foods high in fat and added sugar. Since preschoolers can exhibit neophobia due to a variety of factors (e.g., parent feeding practice, personality, social influences) [29] and neophobia has been associated with lower consumption of fruits and vegetables in preschoolers [30], we assessed the interaction between OM exposure and neophobia on the preschooler's liking as reported by the parent. The second aim was to assess if OM exposure was associated with adiposity among the children, and showed a relationship to liking for vegetables, fruits, and foods high in fat and added sugar.

2. Methodology

2.1. Study design and participants

This observational study included 485 children, ages 3–5 years old, who were enrolled in federal (Head Start) and state (School Readiness) supported preschool programs in two urban centers in Connecticut (2005 population estimates between 60,000 and 110,000). The study was approved by the University of Connecticut Institutional Review Board. To participate, parents signed an informed consent for both themselves and their children.

2.2. Data collection

Data were collected in September/October 2008 as part of preschool program enrollment or during mandatory health screening required within the first 45 days of enrollment. The families of the preschoolers were at or close to the U.S. Federal Poverty Guidelines. The preschoolers had a mean age of 45.4 ± 6.7 SD months and, from parent-reports, were primarily Hispanic (56%) or Black (27%) (Table 1). Using surveys in English or Spanish, parents reported participation in government-supported nutrition assistance and their preschooler's dietary behaviors and history of OM. In addition to reported food likes/dislikes (described below), the dietary behaviors included a dichotomous yes/no response about food allergies, constipation, diarrhea, chewing problems, special diets, and asthma. Data on whether or not the preschooler had been breastfed were available on subset of the entire study sample (n = 279).

2.2.1. Otitis media exposure and neophobia

Following the format of the National Nutrition and Health Examination Survey III (as described in [10]), parents reported how many times their child had an ear infection or earache (never, once, twice, 3 to 5 times, 6 or more times) and whether or not the first ear infection was before age 1 (yes/no). Parental reports of OM exposure have been shown to have reasonable agreement with the number of OM episodes reported in a child's medical record [31–33]. Neophobia was assessed by a dichotomous yes/no response to a single question, “My child is afraid to eat things s/he has never had before,” from the 6-item Child Neophobia scale [30]. Preschoolers with a “yes” response were categorized as neophobic. The justification for a single question in the present study is based on the reports of the scale developers. Two of the 6 items did not test neophobia, and the Cronbach's alpha across the 6 items was .92, showing that response to one item had a high degree of correlation with response to another item.

2.2.2. Preschool adapted liking survey (PALS)

On a horizontal continuous line scale labeled with five faces, parents/caregivers were asked to report their child's likes or dislikes of 18 food/beverages including: fruits (apple juice, strawberries, watermelon); vegetables (carrots, sweet potato/yam, broccoli, spinach/collard greens, corn, tomatoes); fat/sugar foods (cookies/cake, ice cream, soda pop, candy bar, French fries, snack foods/Cheetos/Pretzels/Doritos, butter/margarine), lunch meat/bologna/hot dogs, and whole milk. Interspersed with the foods/beverages were 4 non-food items: 3 pleasurable activities

Table 1
Sex, ethnicity and BMI percentile (85th to 95th percentiles: overweight; > 95th: obese) categories of children in two urban preschool centers.

	Female		Male	
	Na	Mean or %	N	Mean or %
Sex	232	48.0	253	52.0
Reported race				
White	25	10.8	25	10.5
Black	72	31.0	67	28.2
Latino	129	55.6	137	57.6
Asian	1	0.4	1	0.4
American Indian	1	0.4	0	0.0
Other	4	1.7	8	3.3
BMI percentile—overweight				
2 to <3 years	16	18.8	19	5.0
3 to <4 years	106	18.9	108	18.5
4 to <5 years	85	12.9	102	17.7
All (2–5 years)	207	16.4	229	17.0
BMI percentile—obese				
2 to <3 years	16	12.5	19	10.5
3 to <4 years	106	13.2	108	10.2
4 to <5 years	85	10.6	102	18.6
All (2–5 years)	207	12.1	229	14.0

[a] Numbers (N) of preschoolers; the numbers vary due to missing data.

(brushing their teeth, getting dressed, taking a bath) and 1 unpleasurable sensation (sound of a loud siren). The non-food items (alternative reinforcers) were to support the scale as a generalized hedonic scale [27]. The parents were instructed that the ends of the scale represented "the strongest liking or disliking you can imagine." Liking scores were generated by measuring the ±100 point line from the center rating ("he/she thinks it's ok" at 0) to the liking rating ("he/she really likes it" from 30 to 50 and "he/she loves it" from 80 to 100) or to the disliking rating ("he/she really does not like it" from −30 to −50 and "he/she hates it" from −80 to −100).

The PALS was selected as a measure of the preschooler's dietary behaviors as it was feasible for a community-based study and served as a proxy of dietary intake with the assumption that what is liked/disliked drives what is consumed [34,35]. In a separate analysis of data from the present study, liking/disliking responses for fruits and vegetables on the PALS showed a significant correlation with reported intake of these foods and with a biomarker of fruit and vegetable intake (dermal carotenoid status) [36]. The PALS also shows reasonable reliability. Items with similar constructs hold together in statistically reliable groups (e.g., Cronbach's alpha>.7) as shown in Table 2. Longer-term test–retest reliability of the PALS was available on 160 preschoolers, collected 7 to 8 months after the initial survey. The correlation coefficients were reasonable, averaging .33 for the fruits and fat/sugar foods to .48 for the vegetables, particularly because of the long timeframe and that the preschool program strives to compel preschoolers/families to improve the quality of their diet toward higher liking/intake of fruits and vegetables and lower liking/intake of fat/sugar foods.

Liking scores were treated as a continuous variable for parametric analysis of the food groups (fruit, fat/added sugar foods, and vegetables), computing mean liking across the groups (Table 2) and analyzing these means by OM exposure, neophobia and BMI percentile. Liking scores were also used to rank the 22 items from least liked/disliked (rank of 22) to most liked (rank of 1) based on the mean liking score across the No Reported and High OM exposure (6 or more times) categories (Table 3). A mean ranking for the food and pleasurable activities groups was computed based on the rankings of the individual items (Table 3). The percent difference in the average ratings was calculated between and within the No Reported and High OM exposure categories ($(X1-X2)/X1*100$) as described in the Results and shown in Table 4.

Table 2
Average hedonic ratings for preschoolers according to liking groups and individual items from the Preschool Adapted Liking Survey.

	Mean[a]	SD
Fruits (α=0.66)[b]	62.45	35.32
Apple juice	68.41	40.88
Strawberry	60.81	47.67
Watermelon	58.07	48.34
Pleasurable activities (α=0.70)[b]	60.95	35.70
Taking a bath	73.98	40.97
Getting dressed	57.30	47.49
Brushing teeth	51.90	45.87
Fat/added sugar foods (α=0.82)[b]	60.14	30.97
Ice cream	70.89	40.78
Cookies/cake	66.53	37.93
Snack foods (Cheetos, Doritos, Pretzels)	65.61	39.38
French fries	65.04	40.79
Candy bar	57.94	46.48
Soda pop	33.78	54.66
Vegetables (α=0.73)[b]	16.28	38.05
Corn	51.83	51.78
Broccoli	18.21	61.52
Tomatoes	17.90	62.27
Sweet potatoes/yams	8.17	56.41
Carrots	7.41	54.60
Spinach/collard greens	−9.01	58.98
Individual items		
Whole milk	65.05	45.70
Lunch meat, bologna, hot dogs	53.74	47.23
Butter/margarine	25.74	46.30
Loud siren	−4.13	56.07

[a] Mean liking rating where 0 is "he/she thinks it is ok," to ±80 to 100 "he/she loves/hates it.".
[b] Cronbach's alpha statistic as an internal reliability measure of the food group.

2.2.3. Adiposity

The body mass index (wt/ht^2) adjusted to the child's age and sex (BMI percentile) provided a measure of adiposity in a community-based setting. Registered dietitians measured the preschooler's height using a portable Stadiometer (Seca, Hanover, MD) and body weight using a portable, digital scale. The preschoolers had their shoes on during the measurement due to fire code policy and regulation. BMI was calculated as weight (kg)/height (m^2). Using the Centers for Disease Control and Prevention's BMI-for-age growth charts (for either girls or boys), underweight was defined as <5th percentile, healthy weight as 5th to ≤85th percentile, overweight as 85th to ≤95th percentile, and obesity defined as equal or ≥95th percentile.

2.3. Data analysis

Data were analyzed using Statistica (StatSoft, Tulsa, OK). Difference in ranking of liking for foods versus nonfoods was described across preschoolers with no OM exposure versus 6 or more exposure categories. Chi square analysis tested for frequency differences between categorical variables. Analysis of covariance was used to determine the main and interaction effects of OM exposure and food neophobia categories on

Table 3
Ranking of liking of individual items[a] and groups[b] from least to most liked by No and High OM exposure categories among preschoolers.

	No reported OM exposure (n=150)		High OM exposure (n=44)	
	Rank	Food	Food	Rank
Least liked	22	Sound of a loud siren	Spinach/collard greens	22
	21	Spinach/collard greens	Sound of a loud siren	21
	20	Carrots	Sweet potato/yams	20
	19	Sweet potato/yams	Carrots	19
	18	Broccoli	Broccoli	18
	17	Tomatoes	Tomatoes	17
	16	Butter/margarine	Butter/Margarine	16
	15	Soda pop	Getting dressed	15
	14	Brushing teeth	Brushing teeth	14
	13	Lunch meat/bologna/ hot dogs	Strawberries	13
	12	Corn	Soda pop	12
	11	Candy bar	Watermelon	11
	10	Getting dressed	Lunch meat/bologna/ hot dogs	10
	9	Watermelon	Apple juice	9
	8	Strawberries	Corn	8
	7	French fries	French fries	7
	6	Whole milk	Candy bar	6
	5	Snacks, Cheetos, Pretzels, Doritos	Whole milk	5
	4	Cookies/cake	Snacks, Cheetos, Pretzels, Doritos	4
	3	Ice cream	Cookies/cake	3
	2	Apple juice	Taking a bath	2
Most liked	1	Taking a bath	Ice cream	1
Mean ranking for groups	17.83	Vegetables	Vegetables	17.33
	8.33	Pleasurable activities	Fruits	11.0
	7.5	Fat/added sugar foods	Pleasurable activities	10.33
	6.33	Fruits	Fat/added sugar foods	5.5

[a] Calculated from average preference scores across the OM exposure category.
[b] The mean preference ranking across the individual items shown in Table 2 ((e.g., Fruits in No OM exposure=(2 Apple juice+8 Strawberries+9 Watermelon)/3=6.33)).

Table 4
Ranking of liking for high-fat/added sugar foods and pleasurable activities among preschool girls and boys who are reported as having no exposure or high exposure (6 + bouts) to otitis media.

Ranking[a]	Boys			Girls		
	No exposure (n = 67)	6 + bouts (n = 24)	% difference and interpretation	No exposure (n = 81)	6 + bouts (n = 18)	% difference and interpretation
High fat/added sugar foods	8.2	4.7	75% high exposure ranked foods more liked	8.0	6.8	18% high exposure ranked foods more liked
Pleasurable activities	6.7	9.0	34% high exposure ranked activities less liked	9.3	10.0	8% high exposure ranked activities less liked
% difference and Interpretation	20% foods ranked less liked	92% foods ranked more liked		16% foods ranked more liked	47% foods ranked more liked	

[a] Average ranking for the groups (Table 2) across 22 items (Table 3); lower ranking is more liked.

food liking scores and BMI percentile while controlling for age and sex effects. A priori planned comparisons were produced using the error generated by the ANOVA [37]. Standard multiple linear regression was used to predict BMI percentile from OM exposure category, age in months and sex effects [38]; we reported the semipartial correlation coefficient (sr), or unique variance in BMI explained by the independent variable. In all statistical analysis, the significance criterion was $p \leq .05$.

3. Results

3.1. Study sample and characteristics

Thirty-one percent of the preschoolers had a fear of eating new things (similar rates in girls at 28.6% and boys at 32.6%), 7.5% had food allergies, and 2% were on a special diet. Fifty-three percent were from families who said that they received governmental nutrition assistance. The children were generally reported as healthy (7% having constipation, 3% diarrhea, and 2% chewing/swallowing problems), yet 19% had asthma. In the subsample of 279 preschoolers, 49% had never been breastfed, 51% had been breastfed but only 13% for at least 6 months.

3.1.1. OM exposure

Approximately 1 in 3 children had an ear infection prior to age one year and the frequency of ear infections varied across the sample: none (31%), once (22%), twice (22%), three to five times (16%) and six or more times (9%). As expected, children with ear infections before age one (early onset) were more likely to have frequent ear infections ($\chi^2 = 88.52$, $p < .001$). Children with asthma were also more likely to have greater than two ear infections than did those children without asthma ($\chi^2 = 7.47$, $p < .001$). Boys were more likely to have three or more OM infections as compared with girls ($\chi^2 = 4.322$, $p < .05$), an effect independent of age, although boys were not more likely than girls to have an OM occurrence before the age of one ($\chi^2 = .79$, $p = .38$). Participation in nutrition assistance programs did not vary with reported frequency of ear infections. Nonetheless, children of participating families tended to be more likely to have an ear infection before the age of one than children of non-participating families ($\chi^2 = 3.53$, $p = .06$).

3.1.2. Food liking

The liking scores formed four statistically reliable groups for analysis (Table 2), with average hedonic ratings for fruits, non-foods, and fat/sugar foods averaged just above the “he/she really likes it” rating and did not show significant average differences across boys and girls.

3.1.3. Adiposity (BMI percentile)

Based on measured weight/height and age/sex-specific BMI percentiles, 4% were underweight, 17% overweight, and 13% obese (≥95th). BMI percentile showed a small but significant increase with age, significant in males ($r = .13$, $p < .05$). The overweight/obesity rates for Blacks and Latinos were roughly equal, although black girls showed higher rates of overweight but lower rates of obesity than black boys.

3.2. OM exposure and food liking

3.2.1. Fruit and vegetable liking

In analysis of covariance (ANCOVA) controlling for age, sex, race/ethnicity, nutrition assistance participation, and non-food hedonic ratings, there was a significant effects of OM category for vegetables [$F(4,435) = 2.75$, $p < .05$] and fruits [$F(4,435) = 3.26$, $p = .01$]; preschoolers in the top two OM exposure categories had significantly lower liking for the vegetable (Fig. 1) and fruit (Fig. 2) groups than those with no or a single exposure to OM. The vegetable group was ranked as least liked by both lowest and highest OM exposure groups (Table 3). The fruit group was ranked 74% more liked in the lowest OM exposure than in the highest exposure category.

3.2.2. Fat/added sugar liking

The OM category effect on average liking scores for the fat/sugar foods was not significant [$F(4, 429) = .95$, $p = .44$]. However, there were differences in ranking between the exposure groups (Table 3). The fat/sugar foods achieved a 36% higher rank toward most liked by the High OM than the No OM exposure categories. The relative ranking of fat/sugar foods to pleasurable activities also differed between OM exposure groups—they achieved nearly equal ranking in the no OM exposure preschoolers, yet among the High OM exposure preschoolers, the fat/

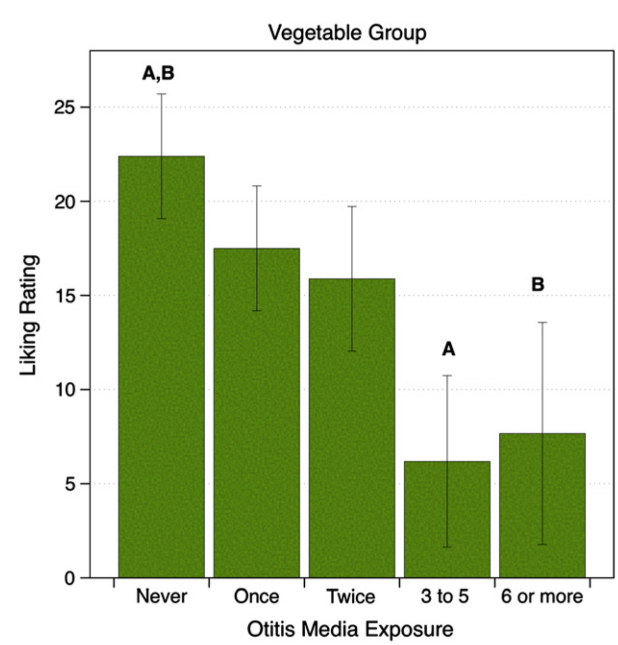

Fig. 1. Parent-reported liking for the vegetable group among preschoolers by otitis media exposure category [$F(4,435) = 2.75$, $p < .05$]; categories with the same superscript are significantly different ($p < .05$).

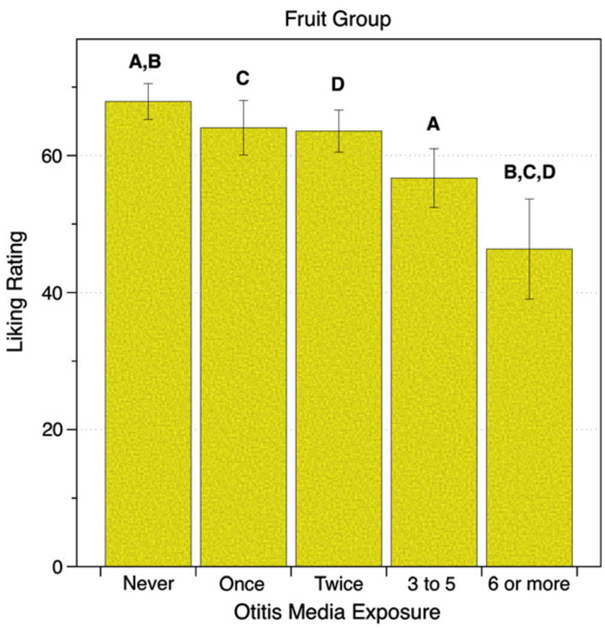

Fig. 2. Parent-reported liking for the fruit group among preschoolers by otitis media exposure category [F(4,435) = 3.26, p = .01]; categories with the same superscript are significantly different (p < .05).

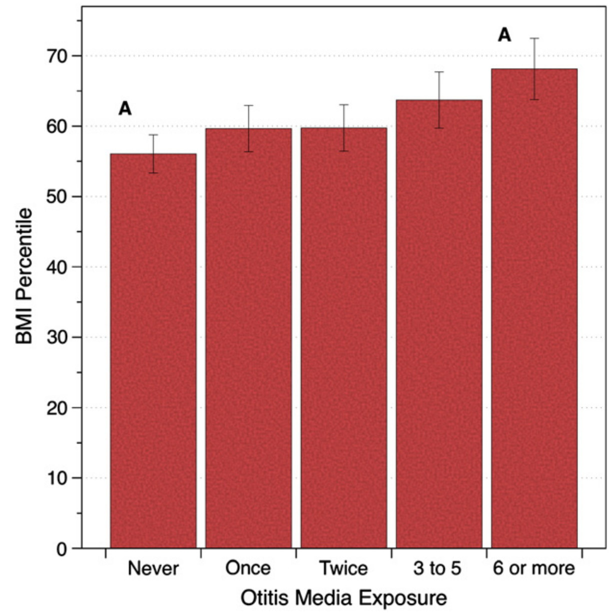

Fig. 3. BMI percentile by otitis media exposure category [F(4,419) = 1.34, p = .26]. Categories sharing the same superscript are significantly different (p < .05).

sugar foods were ranked over 80% higher than the pleasurable activities. As summarized in Table 4, the higher ranking of fat/sugar foods relative to pleasurable activities in the highest OM exposure category was more pronounced in boys than in girls.

3.2.3. Food neophobia, OM exposure and food liking

In a similar ANCOVA, preschoolers with food neophobia reported less liking for the vegetable [F(1, 435) = 28.75, p < .001] and fruit [F(1, 435) = 17.53, p < .001] groups but not the fat/added sugar group (F(1, 435) = 2.83, p = .10). In a two-way ANCOVA on liking for the vegetable group, there were significant main effects of OM exposure [F(4,419) = 2.47, p = .05] and neophobia [F(1, 419) = 26.15, p < .001] categories. In pairwise comparisons, preschoolers with higher neophobia had significantly less liking for vegetables across each of the OM categories, significant (p < .05) for all except the "once" OM exposure category. The lowest average vegetable liking was seen in preschoolers with neophobia and with highest OM exposure. Similarly for the fruit group in a two-way ANCOVA, there were significant main effects of OM exposure [F(4,419) = 4.36, p < .001] and neophobia [F(1, 419) = 17.65 p < .001] categories. In pairwise comparisons, preschoolers with higher neophobia had significantly less liking for fruits across each of the OM categories, significant (p < .05) only for the 3 to 5 and 6 or more OM exposure categories (p < .001). The lowest average fruit liking was seen in preschoolers with neophobia and with highest OM exposure. For both ANCOVAs, the interaction between OM exposure and neophobia was not significant (p > .10).

3.3. Adiposity, food liking and OM exposure

Liking for the vegetable and fruit groups failed to show a significant association with BMI percentile. However, there was a small but significant association between greater liking for fat/added sugar foods and BMI percentile (sr = .12, p < .05), independent of non-significant associations of age, sex, nutrition assistance participation, or race. In ANCOVA, preschoolers with greatest OM exposure averaged a BMI percentile greater than those without this exposure (Fig. 3). Notably, the distribution of BMI percentiles varied across the highest and lowest OM exposure categories, as shown in Fig. 4 comparing the no OM versus the 3 to 5 and the 6 or more OM exposure categories. The distribution of the highest exposure categories grew more rapidly toward higher BMI with maximal separation between the 60th and 85th percentiles (K–S statistic: D = .18, p < .05). Because BMI percentile appeared to grow in a linear fashion with OM frequency category, a multiple linear regression model was constructed to predict BMI percentile from frequency category and demographic variables as covariates. Ear infection category was a small, but significant independent contributor (sr = .13, p = .01). Food neophobia only tended to associate with a higher BMI percentile [F(1, 396) = 2.75, p < .10].

4. Discussion

4.1. General findings

Factors associated with excessive adiposity in children are of great interest as the rates of childhood obesity increase. The present study examined the relationship between reported OM exposure, diet and adiposity in a large, community-based sample of preschoolers. Because of poor socio-economic conditions and environments, these preschoolers are likely to have higher risk of OM [39], dietary inadequacies [40] and obesity [41]. In the present study, preschoolers with higher OM exposure had dietary preferences that could associate with greater energy intakes and excessive adiposity — less liking for fruits and vegetables but greater affinity for foods high in fat and added sugar. The level of adiposity, assessed by BMI percentile, differed across OM exposure in a linear fashion. The distribution of BMI percentiles among those with highest exposure was skewed toward higher percentiles compared to those with No Reported exposure, although the number of overweight and obese children between the highest and the lowest exposure was not different.

4.2. OM exposure

The reported exposure to OM in our sample of 69%, with higher rates in males and those with asthma, is equivalent with U.S. national statistics and prevalence of 68.2% [10]. Children of economic disadvantage are likely to be exposed to environments that increase risk of OM as well as have less access to healthcare for prevention and treatment of OM and its side effects [39]. From a subsample of the present study, breastfeeding rates were below U.S. national averages [42] for ever breastfed (51%

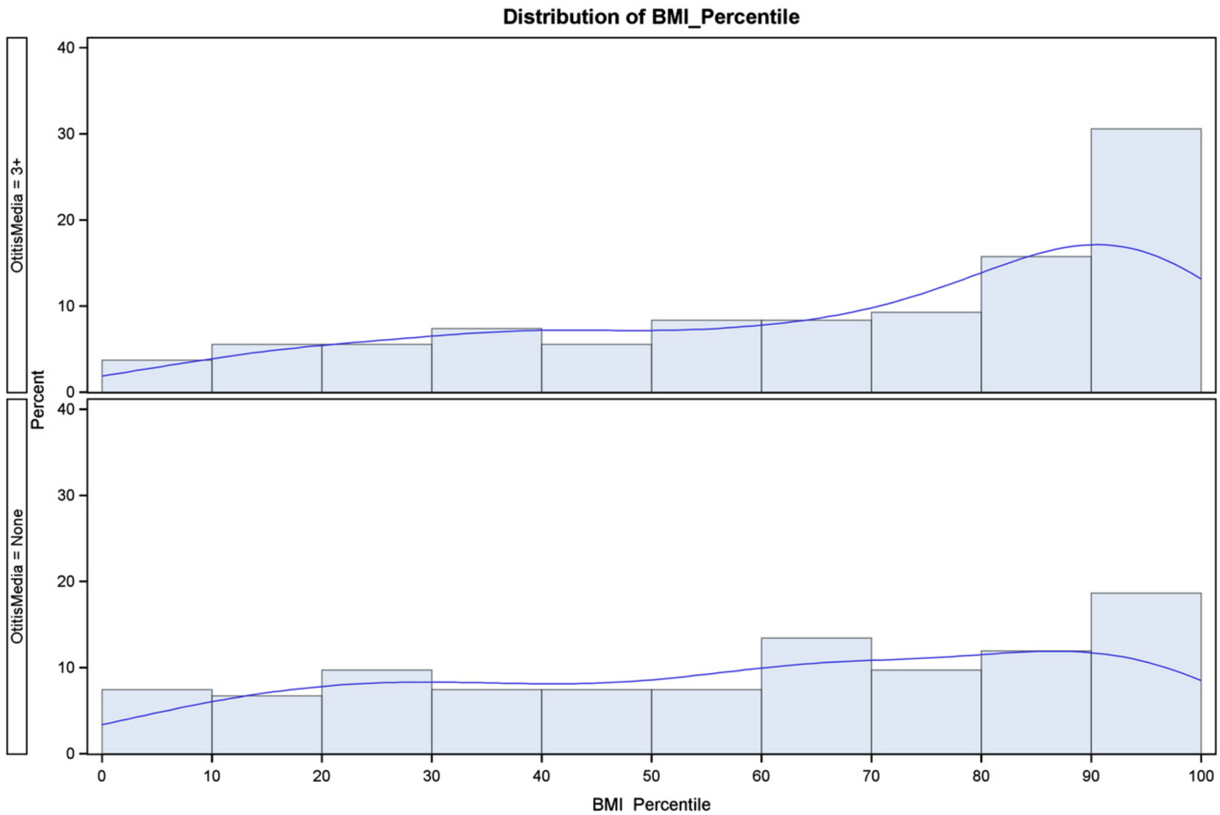

Fig. 4. The distribution of BMI percentiles among preschoolers with 3 or more exposures to otitis media (top graph) and with no reported exposure to otitis media (bottom graph).

versus 74.6%) or breastfed at 6 months of age (13% versus 44.3%), which also contributes to higher risk of OM [10]. Because of policy changes to the structure of support for income-challenged families in the US, government supported preschools may not reach the most economically disadvantaged children [43] and those at greatest OM risk.

4.3. Food liking as a proxy for dietary intake

The present study included the Preschool Adapted Food Liking Survey (PALS), a parent-reported, assessment of dietary behaviors in preschoolers. The preschoolers preferred high fat, sweet and salty foods and liked vegetables least, which is consistent with innate preference for sweet, innate/early learned response to salty, and dislike of bitterness [5], a primary component of disliking for vegetables and unripe fruits [44]. These liking patterns also are consistent with dietary patterns of young children from the 2004 Feeding Infant and Toddlers Study [45], who were most likely to consume high-fat, sweet tasting foods and less likely to consume vegetables.

Survey assessment of food preferences may serve as a proxy of dietary intake according to several lines of evidence. Preference is an important determinant of intake in young children [34,35] and there is reasonable correlation between reported preference and intake among children [46–48]. However, asking what is liked or disliked may in fact be a more accurate measure of usual intake than asking what is usually consumed. It is cognitively simpler to recall affect than it is to recall specific behaviors [49]; the PALS took less than half of time for parents to complete than a food frequency screener of an equivalent number of items. Measures of food intake are notoriously inaccurate because individuals underreport the consumption of less healthy foods (e.g, fat, sweet) while over-reporting consumption of healthy foods (e.g, fruits, vegetables) [50,51]. Parents may be more able or willing to tell you what they or their child likes than what is actually consumed. Reported liking for high-fat foods, for example, shows stronger relationships to diet-related health measures than do reported intake of these foods [52,53]. The present study found a significant, although modest, association between liking for fat/added sugar foods and BMI percentile. In a concurrent analysis, parental responses on the PALS for fruits and vegetables showed a closer relationship between fruit and vegetable liking and dermal carotenoid status, a biomarker of fruit and vegetable intake, than did reported intake of these foods [36]. The PALS also allowed the assessment of the relative ranking of foods versus pleasurable non-food activities. Children and adults who are overweight/obese may have greater motivation to eat palatable foods and eat more to obtain the positive reinforcement from food [54] and this motivation can be assessed in laboratory-based settings and with questionnaires [55].

4.4. OM exposure and food liking

Infectious agents associated with OM could influence taste and oral sensations by altering the taste input from the chorda tympani nerve as shown by experimentally [13,56], clinically [14,15,57], including in studies with children [16]. The present study found lower liking for vegetables and fruits as the OM exposure increased from none to ≥6 bouts. These data are consistent with an earlier pilot study from our laboratory, which reported lower intakes of fruits and vegetables among a small sample of low-income, urban preschoolers, collected through multiple home visits [28]. Differences in bitterness and oral sensations from vegetables and fruits could explain some of these OM effects. Drawing on inferences from a study associating orosensory variation with vegetable sensations and consumption [20], high OM exposure may increase unpleasant bitter sensations from vegetables enough to suppress the endogenous vegetable sweetness, resulting in lower vegetable liking. A similar pattern may occur with the tastes of fruits and OM exposure. High OM exposure also could enhance the textural experiences from foods because of loss of input from the taste system, resulting in subsequent increases in somatosensory sensations [15]. Texture/mouthfeel and appearance join taste as important drivers of fruit and vegetable preference of young children [58]. Thus, it is plausible that children with high OM exposure could have lower vegetable/fruit liking because of pronounced texture, similar to children showing tactile or oral defensiveness [59] or picky eating behaviors in children with autism spectrum disorders [60].

Texture is also an important component in the liking for high-fat foods, with positive associations for creamy and smooth and negative associations for oily and greasy sensations. Following the hypothesis that OM exposure influences food liking through oral sensations, there is evidence suggesting that oral sensations from fat are more preferred among individuals, especially males, with reported exposure to OM [27]. The association between OM exposure and fat preference may be more apparent in adult and preschool males because males have a greater prevalence of OM [10]. In the present study, average liking for fat/sugar food was not significantly different based on OM exposure. However, these foods were ranked as more preferred than other pleasant non-food activities among the preschoolers with highest OM exposures, and this was most pronounced among the boys. It may be that parents are less able to report the degree of liking that their child shows for food, but this enhanced affinity was apparent by showing the relative high affinity toward high-fat/sweet foods compared to other pleasant experiences (alternative reinforcers). Following the evidence that obese individuals have an elevated reinforcing value for food [54], high exposure to OM could increase the risk for excessive adiposity via greater attention to and reinforcing value from the fat/sweet sensory characteristics of foods for pleasure, leading to overeating these foods and energy overconsumption.

4.5. OM exposure and neophobia exert separate influences on vegetable/fruit liking

Neophobia, a fear of negative consequences from ingesting a food [61], manifests most frequently as a behavioral rejection of fruits, vegetables and protein foods in children [30]. This fear of food ingestion has been shown to work independently from unpleasant taste sensations [62] as well as from genetic propensity to experience heightened bitterness [63] to hinder vegetable intake in preschoolers. The present study is consistent with these previous findings that high OM exposure could alter the oral sensations from vegetables independently from the affects of neophobia. Children who are food neophobic may dislike the idea of putting vegetables and fruits into their mouth whereas the influence of OM and heightened oral sensations occurs after the food is orally manipulated. Consistent with previous findings, boys in our sample were more likely to be food neophobic than were the girls [64].

4.6. OM exposure and adiposity

The rates of overweight and obesity seen in the present study are congruent with 2009 US data from the National Health and Nutrition Examination Survey for low-income preschoolers [65]. These data also are consistent with other studies reporting associations between greater OM exposure and greater overweight/obesity [23–26] and suggest that diet links elevated OM exposure to elevated body weight via lower affinity for less energy dense foods and higher affinity for food and high energy dense foods. Diets high in fruits and vegetables, particularly vegetables that can be bitter, support lower adiposity and high bone mass in young children, whereas higher fat intake is associated with higher body fat [66]. Alternatively, high exposure to OM also may be a proxy measure of impoverished environmental conditions [39] which in turn increases the risk of overweight/obesity through limited access to healthy foods [67], adequate levels of physical activity [68], or greater exposure to environmental hazards such as smoking [69], and lack of healthcare [70]. Thus, it remains possible that OM exposure could associate with level of adiposity through other non-taste mechanisms. For example, the infection that causes the OM could influence the levels of appetite-regulating gut hormones [71].

4.7. Strengths, limitations and conclusions

The primary strength of this study was testing the association between OM exposure and adiposity in a community-based setting with a large number of preschoolers who were diverse in ethnicity/race. Present work extends prior reports by providing evidence that some of the relationship may be explained through dietary preferences. The PALS method to assess the preschoolers' food likes and dislikes was feasible in the field and served as a proxy for dietary intake. However, because of the community-setting, OM exposure was reported by the parent/caregiver and not verified by healthcare records. Previous studies have shown reasonable agreement between parent and medical chart reporting of OM exposure [31–33], although less clear is the level of agreement among families of income disadvantage who may have inconsistent access to healthcare. As with any cross-sectional study, these data do not imply a causal relationship between OM exposure, food preference and adiposity. Nonetheless, they highlight the need to continue researching OM as a potential contributor to dietary behaviors and growth in children.

In summary, taste and oral sensations are primary determinants of what children consume. High exposure to OM, a common childhood ailment, could alter the tastes and oral sensations of foods and beverages by altering taste function on the anterior tongue (i.e., chorda tympani taste nerve damage). From parent reports, the present study found preschoolers with high OM exposure had less preference for fruits and vegetables, greater affinity for high-fat/sweet foods, and higher adiposities than did preschoolers with the lowest OM exposure. Although the number of cases of OM has declined over the last decade due to the increasing number of households that are smoke free and the 7-valent pneumococcal conjugate vaccination [72], the rates of OM are still high in children especially those who are medically and economically underserved. This study joins others that find a relationship between OM exposure and adiposity, suggesting the utility of assessing exposure to OM as part of the screening for risk factors of poor dietary quality and risk of overweight and obesity among children. Further research on effects of OM exposure on obesity risk in preschoolers is necessary to whether this association is causal.

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