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Adolescent eating in the absence of hunger and relation to discretionary calorie allowance

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Abstract

Eating in the absence of hunger (EAH) is a risk factor for overeating during childhood. The objective of this study was to examine EAH in adolescents based on their familial predisposition to obesity and current weight status. Thirty-one subjects (16 males, 15 females), who were 13 years of age and born at low-risk (LR) or high-risk (HR) for obesity, consumed lunch to fullness. After lunch, subjects had access to different snacks for 15 minutes. EAH referred to energy intake from the snacks. LR females consumed two and a half times more calories from snacks than HR females, and twice as many calories as LR and HR males when expressed as an individualized percentage of daily allowance for discretionary calories. Normal-weight females consumed two and a half times more calories from snacks than obese females and normal-weight males. The association between EAH and weight and obesity risk status depended on adolescents' sex and could reflect emerging developmental differences, such as dieting or social desirability.

Keywords

Eating in the absence of hunger; energy intake; discretionary calories; obesity; adolescents

Introduction

Eating in the absence of hunger (EAH) is a trait which refers to children's susceptibility to eating when satiated in response to the presence of palatable snacks. EAH has been shown to be stable over time in young girls (1,2) and to be positively correlated with weight during childhood (3). To date little is known about EAH in adolescents. It is possible that developmental changes during puberty and an emerging awareness of appearance may produce sex-dependent differences in EAH in adolescents.

The 'Infant Growth Study' (4-6) is a longitudinal study of growth and development in children who were classified at birth as being at high risk (HR) or low risk (LR) for obesity on the basis of their mothers' pre-pregnancy body mass index (BMI; kg/m²); they have been followed for 15 years. Maternal obesity has been identified as a strong risk factor for obesity in offspring (7) with the uterine environment (8,9) and early child feeding practices (10) being implicated in this transmission of obesity risk. The primary aim of this study was to compare adolescents from this study on EAH on the basis of their familial predisposition to obesity and current weight status. It was hypothesized that HR and overweight/obese youth would show greater EAH than LR and normal-weight youth.

A secondary aim was to describe EAH in relation to adolescents' discretionary calorie allowance. Discretionary calories refer to the difference between energy requirements and energy consumed to meet recommended nutrient intakes (11). The discretionary calorie allowance ranges from 154 to 334 calories/day depending on the individuals' estimated energy requirement (EER) based on age, sex, and body size and includes intake of added fats and added sugar.

Methods

Experimental Design

EAH was assessed by the ‘free access procedure’ during which subjects had unrestricted access to a variety of snack foods (1,12,13). Specifically, following the ingestion of lunch, subjects had access to different snack foods for 15 minutes. EAH refers to the number of calories consumed from the snacks while being fully satiated.

Subjects

Subjects, all of whom were Caucasian, were enrolled in this study at three months of age and have since undergone annual assessments. Mothers were recruited from Pennsylvania hospitals. Inclusion criteria for mothers were: being Caucasian, pre-pregnancy BMI less than the 33rd percentile or greater than the 66th percentile, gave birth to a healthy full-term infant, no gestational diabetes, and ≥ 18 years of age (14). Mothers of HR and LR children averaged pre-pregnancy BMIs of 31.2 kg/m² and 19.4 kg/m².

For this most recent assessment, subjects were contacted within three months of their 13th birthday. Thirty-one subjects (16 males, 15 females) out of the 81 original subjects were available for the Year 13 assessment. Subjects reported to the laboratory individually over a period of 20 months. Written informed consent was obtained from the parents and assent was obtained from the youth. The study protocol was approved by the Institutional Review Boards of the University of Pennsylvania and The Children's Hospital of Philadelphia (CHOP) in Philadelphia.

Procedures

On the day of their visit, subjects were instructed to consume a typical breakfast and to refrain from eating or drinking (except water) from the time they finished their breakfast (before 9:00 A.M.) until lunch, which was provided during their visit. Upon arrival at the Center for Weight and Eating Disorders at 10:00 A.M., subjects were escorted to CHOP for body composition assessment. Lunch was served at the Center at 12:00 P.M. and consisted of white bread, turkey, ham, American cheese, lettuce, tomato, mayonnaise, mustard, cheese pizza, macaroni and cheese, apple, banana, cola, diet cola, and water. The meal contained ~3,660 calories and was consumed *ad libitum*. Subjects were not told that they were going to be offered snacks after lunch.

After lunch, subjects waited for 10 minutes before being escorted to another room. There, snacks were presented in two-quart glass canisters and included chocolate chip cookies, chocolate, M&M's, jelly beans, Skittles, potato chips, Fig Newtons, pretzels, popcorn, peanuts. Subjects were told that they had some downtime for 15 minutes. They were instructed that they could help themselves to any of the snacks and were provided with magazines. Study staff left the room and subjects were left entirely alone for the duration of the EAH assessment. Subjects' parents waited in a separate room for the duration of the visit.

Assessment of appetite

Immediately before and after lunch, subjects rated their hunger, thirst, prospective consumption, nausea, and fullness using 100-mm Visual Analog Scales (VAS) with opposing anchors (e.g., “not at all hungry” and “extremely hungry”) (15). After lunch, subjects also rated how typical the amount was that they ate (i.e., “less than typical” and “more than typical”). To ensure that all subjects ate to fullness, study staff verified that after-meal hunger ratings were below 35 mm and verbally confirmed with subjects that they were no longer hungry. All subjects indicated that they had eaten to fullness.

Assessment of food intake

The lunch and snacks were prepared in the research kitchen. All foods and beverages were pre-weighed by trained research assistants prior to being served to subjects and re-weighed after subjects had finished eating to the nearest 0.1 gram. Amounts consumed from foods and beverages were determined by subtracting post-meal weights from pre-meal weights. Nutrition information from food manufacturers and from the Food Processor SQL software (ESHA), version 9.8 (2005, ESHA Research, Salem, OR) was used to calculate the number of calories consumed at lunch and from snacks. Because participants included both males and females who varied in body size, energy intake at lunch was expressed as a percentage of their EER and energy intake from snacks was expressed as a percentage of their estimated allowance for discretionary calories, rather than as absolute calories.

The computation of subjects' EER was based on age-, sex-, and weight-, and height-specific equations (16). The specific allowance for discretionary calories for each subject was based on values provided by the 2005 Dietary Guidelines Advisory Committee (11). For the estimation of subjects' EER and discretionary calorie allowance, the physical activity coefficient was set to be 1.00 (i.e., sedentary) for all subjects.

Anthropometric assessment

Subjects' height and weight were measured in triplicate by trained anthropometrists with subjects wearing light clothing and with shoes removed. Weight was measured on a digital scale (model 6002; Scaletronix, Carol Stream, IL, accurate to 0.1kg). Standing height was measured on a stadiometer (Holtain, Crymch, United Kingdom, accurate to 0.1cm). The mean for each parameter was used for statistical analyses. BMI percentiles and z-scores for subjects were calculated with age- and sex-specific reference data. Subjects were classified as normal-weight (BMI-for-age 5–84th percentile), overweight (BMI-for-age 85–94th percentile), and obese (BMI-for-age ≥95th percentile) according to the Centers for Disease Control and Prevention growth reference standards (17).

Statistical analysis

Data were analyzed using SAS software (Version 9.1. for Windows; SAS Institute, Inc., Cary, NC). Due to the small sample size, the two BMI categories 'overweight' and 'obese' were combined into one weight category ('obese').

Independent-samples t-tests were used to compare subject characteristics (height, weight, BMI, BMI z-score, estimated energy requirement, discretionary calories) and energy intake at lunch by risk and weight group. For all VAS ratings, nonparametric Mann-Whitney U tests were used to compare means between risk and weight groups.

A 2 (risk group) × 2 (sex) general linear model analysis of variance (ANOVA) tested simultaneously the main effects of risk group and sex on EAH (expressed as a percentage of subjects' daily estimated allowance for discretionary calories). Second, a 2 (weight group) × 2 (sex) general linear model ANOVA tested simultaneously the main effects of weight group and sex on EAH. The interactions between risk group and sex and weight group and sex were tested for significance and removed if not significant.

Data are presented as model-based means ± SEM. *P*-values < 0.050 were considered statistically significant.

Results and Discussion

Subject characteristics

The sample included 15 LR subjects (8 males, 7 females) and 16 HR subjects (8 males, 8 females). HR subjects, compared to LR subjects, had a significantly higher BMI (25.2 ± 1.8 vs. $18.4 \pm 0.7 \text{ kg/m}^2$; $p=0.01$), BMI z-score (1.16 ± 0.26 vs. -0.39 ± 0.32 ; $p=0.001$), and EER (2340 ± 140 vs. $1918 \pm 109 \text{ kcal/day}$; $p=0.01$). The number of subjects considered normal-weight, overweight, and obese were six, four, and six for HR subjects, and 13, two, and zero for LR subjects, respectively. The difference in the discretionary calorie allowance between HR ($226 \pm 11 \text{ kcal/day}$) and LR subjects ($199 \pm 10 \text{ kcal/day}$) was not significant ($p=0.08$).

Appetite Ratings and Lunch Intake

None of the differences in pre- and post-meal appetite ratings were significantly different between risk ($p>0.1$) or weight groups ($p>0.1$).

There was no significant difference in energy intake at lunch between HR and LR subjects (%EER: 26 ± 4 vs. 32 ± 4 ; $p=0.29$). There was a significant difference in lunch energy intake between weight groups indicating that obese subjects consumed less energy than normal-weight subjects (%EER: 19.9 ± 3.2 vs. 34.6 ± 2.9 ; $p=0.002$).

Eating in the Absence of Hunger

The mean energy intake from snacks for groups combined was $293 \pm 43 \text{ kcal}$ (95% CI: 204, 381 kcal), which when expressed as a percentage of participants' daily discretionary calorie allowance, amounted to an intake of $137\% \pm 20$ (95% CI: 96, 178%). Sixty-one percent of youth consumed more than their daily allowance for discretionary calories ($>100\%$) from snacks and 23% of youth consumed more than twice their daily allowance for discretionary calories from snacks.

There was a significant obesity risk status-by-sex interaction ($p=0.045$) on EAH indicating that LR females consumed significantly more calories from snacks than HR females ($247\% \pm 37$ vs. $89\% \pm 35$; Diff: 157%; 95% CI: 53, 262%). LR females also consumed significantly more calories than LR males ($247\% \pm 37$ vs. $117\% \pm 35$; Diff: 130%; 95% CI: 26, 235%) and HR males ($247\% \pm 37$ vs. $108\% \pm 35$; Diff: 139%; 95% CI: 34, 243%) (Figure 1A). When adjusting for subjects' lunch energy intake, the interaction was no longer significant ($p=0.09$) suggesting a possible carry-over effect of lunch intake on EAH in some subjects.

There also was a significant weight status-by-sex interaction ($p=0.01$) on EAH indicating that normal-weight females consumed significantly more calories in the absence of hunger than obese females ($231\% \pm 35$ vs. $85\% \pm 37$; Diff: 146%; 95% CI: 41, 250%). Normal-weight females also consumed significantly more calories than normal-weight males ($231\% \pm 35$ vs. $93\% \pm 30$; Diff: 138%; 95% CI: 44, 232%), but their snack intake did not differ significantly from obese males' snack intake ($231\% \pm 35$ vs. $155\% \pm 44$; Diff: 76%; 95% CI: -39, 191%) (Figure 1B). When adjusting for subjects' lunch energy intake, the interaction remained significant ($p=0.01$).

This study showed that EAH in adolescents differed as a function of their sex, weight status, and risk status for obesity. LR girls consumed two and a half times more calories in the absence of hunger than HR girls, and twice as many calories as LR or HR boys. A similar pattern of EAH was seen with respect to subjects' weight status.

In this study, more pronounced EAH was found in adolescent *girls*, and only those who were born at LR for obesity or who were normal-weight. When EAH was assessed

previously in this cohort when subjects were 5 years of age, findings showed that HR *boys* consumed significantly more calories in the absence of hunger than LR boys, but EAH did not differ significantly between LR and HR girls (18). This divergence in findings may point to important developmental differences in children's eating behavior before and after puberty.

Previous studies have shown that parental overweight is a significant predictor of daughters' susceptibility to EAH (19,20). In the current study, however, HR girls showed *less* EAH than LR girls. It is possible that HR females, the majority of whom were obese, may have moderated their intake in the laboratory because they may have suspected that their intake was to be monitored. Hill and colleagues (21), who showed that EAH was positively associated with adiposity in pre-pubertal boys, but not girls, speculated that girls who perceive themselves as overweight may suppress their intake in the laboratory to respond in a socially desirable manner. The rise in body dissatisfaction following puberty, particularly in girls (22), may contribute to the attempt of obese girls to restrict their caloric intake (23), particularly when presented with a wide range of energy-dense snacks.

Teens in this study, on average, consumed 293 calories from snacks in this single sitting despite being satiated and many of them greatly exceeded their daily allowance for discretionary calories. Future studies should assess youth's intake over a longer period of time (e.g., 24 hours) to also account for discretionary calories consumed at subsequent meals and snacks. It will also be important to assess if the excess calories consumed in the absence of hunger were compensated at subsequent meals.

The strengths of this study include the measured, as opposed to self-reported, intake in adolescents and the use of a high risk design for obesity in which subjects with different familial predispositions to obesity were assessed. There are limitations to the study. First, the sample was small and homogeneous with respect to race which precludes generalization of the findings to other adolescents. Second, the study used an estimated, rather than observed, measure of physical activity for the computation of participants' EER and daily allowance for discretionary calories. Third, the study could not discriminate between genetic and environmental influences on EAH.

In conclusion, the association between EAH and youths' weight and obesity risk status depended on their sex. Future studies should examine how developmental differences between males and females during puberty, especially with respect to perceptions about their weight, may impact their eating behaviors. It is possible that dissimilarities in the internalization of ideal body perceptions or sociocultural attitudes may differentially affect eating behaviors of adolescent males and females.

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Figure 1. Mean ($\pm$ SEM) energy consumed from snacks by obesity risk group (low-risk: n=15; high-risk: n=16) (Panel A) and weight group (normal-weight: n=19, obese: n=12) (Panel B).