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ORIGINAL PAPER

Eating in the Absence of Hunger and Obesity Among Adolescents in Santiago, Chile

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Abstract

In reports among mostly, US, white, preschool and young school-age children eating in the absence of hunger (EAH) has been positively related to adiposity, with some support for a sex-specific relationship. There is considerable interest in EAH and obesity in populations at risk for obesity—like populations of countries that have undergone rapid development. We assessed adolescents (n = 679) after an overnight fast with anthropometry and an EAH paradigm beginning with an ad lib pre-load meal. Participants reported satisfaction and perceived ability to eat more food, and then proceeded to a room with freely available snacks where they were permitted to eat ad lib for 20 min. Adolescents were 16.8 years old, 52% male, and 14% with obesity. Median preload meal kcal consumption was 602 (IQR 474–746). Additional calories were consumed at the EAH snack by 47.6%. Among those who ate snack, 155 additional calories were consumed (IQR 78–283). Adolescents with obesity had 0.61 (95% CI 0.37–0.99) reduced odds of eating at the EAH snack adolescents without obesity. Adolescents with obesity were also less likely to eat above the median total calories compared to adolescents without obesity (OR = 0.59, 95% CI 0.36–0.96). A sex by obesity interaction term was not significant in any model. Obesity was related to eating behavior in our sample of Chilean adolescents, however not in the direction we hypothesized. Adolescents with obesity were less likely to eat additional calories in the EAH paradigm and ate fewer total calories compared to adolescents without obesity.

Keywords Eating in the absence of hunger · Obesity · Adolescence · Sex differences · Chile · Eating habits

Abbreviations

EAH Eating in the absence of hunger
INTA Institute of Nutrition and Food Technology

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Introduction

The rise in childhood obesity has created a worldwide epidemic, affecting the public health of developed and developing nations. The World Health Organization estimates that over 340 million children and adolescents were overweight or obese, a problem which is prevalent in both high and low- and middle-income countries [33]. Chile, a country which experienced a rapid epidemiological and nutrition transition, has not been spared. In 2015, 25% of Chilean children under 6 years old were affected by obesity, up from < 5% in 1980, 7% in 1987 and 21% in 2010 [2, 14, 23]. Among Chileans 15 years and older, recent statistics show an obesity prevalence of 31.2% [26].

Understanding how the development of obesity relates to eating behavior is important, especially in the context of obesogenic environments with increased access and availability of affordable, energy-dense foods. The complex biological system of satiety and hunger that exists to regulate eating and achieve energy homeostasis [13], can be overridden. Both children and adults often eat when not hungry and eat to excess, essentially favoring external cues to eat rather

than internal signals that indicate satiety. An experimental method of measuring this behavior, 'eating in the absence of hunger' (EAH), was developed by Birch and Fischer [8] and has been used in a variety of studies of children and, to a lesser degree, with adolescents [19, 20, 22, 32] and young adults [1]. The experiment begins with a meal—often a lunch or dinner—after which satiety and satisfaction are determined, often by using a visual analogue scale [18] in which the participant reports feelings of hunger, satiety, ability and desire to eat more food. Shortly after the meal and reporting satiety, the participant is exposed to ad libitum snacks and alternative activities (e.g., magazines, puzzles) to evaluate eating behavior when hunger is not a factor.

Determining risks for susceptibility to obesogenic environments remains an important area to investigate. Many studies have found a positive relationship between EAH and weight status, with most studies finding that being overweight/obese relates to greater caloric intake in an EAH experiment [4, 7, 15, 32]. Several studies, however, have suggested that the relationship between overweight/obesity and EAH may be sex-specific and may not always be in the expected direction. For example, studies have reported that females with obesity, but not males, were less likely to eat during an EAH assessment [27] and eat significantly less [16, 22] when they did eat. At least one study found no relationship between EAH and body composition [11].

While the majority of EAH studies have been conducted with non-Hispanic white populations in the US, EAH has been studied to a lesser degree among Latinos in the US [4, 9] and in Chile [17, 29]. It may be particularly important to study EAH in Chile, as the country has made important and rapid strides in economic development and decreasing poverty, from 39% in 1990 to < 14% in 2006 [14]. Thus, expendable income that allows purchasing energy dense "snacking food" may be a fairly recent phenomenon for many in Chile. In fact, sales of processed foods and beverages has steadily increased in Chile between 1999 and 2013, with Chile being the country with the second largest consumption of both products among 13 Latin American countries [6]. The purpose of the current study was to test whether obesity status related to EAH in a sample of Chilean adolescents. We explored associations overall and stratified by sex. We hypothesized that participants with obesity would eat more in the absence of hunger and eat more overall and that a similar relationship would be observed in males and females.

Materials and Methods

We studied 679 adolescents who were part of a longitudinal cohort that began in infancy as part studies related to iron deficiency anemia [25, 30]. Detailed descriptions of the original studies, including inclusion criteria, have been described elsewhere [25]. In sum, healthy infants who weighed ≥ 3 kg at birth from four low- to middle-socioeconomic neighborhoods in Santiago, Chile were recruited. Participants who, at 6 months of age, did not have iron deficiency anemia entered a preventive treatment trial (n = 1657) [25]. Infants with iron deficiency anemia and the next healthy control were treated as part of a parallel neuromaturation study [30]. Between the two infancy studies, a total of 1792 infants participated from 1991 to 1996 [28]. At 16 years, a random sample of the original infancy cohort was invited to participate in a study of obesity cardiovascular risk. The study was approved by the Institutional Review Boards at the University of California, San Diego and the Institute of Nutrition and Food Technology (INTA), University of Chile, the study site in Chile in accordance with the Declaration of Helsinki. All adolescents provided assent and their parents provided consent for their participation.

Participants arrived at the study site between 8 and 9 a.m. The assessment began after reviewing study procedures and answering any questions about the informed consent document. Adolescents were weighed and measured at INTA in minimal clothing according to standard methods by a research physician [24]. Weight was measured to the closest 0.1 kg, using a Seca scale, and height to the closest 0.1 cm, using a Holtain stadiometer. Measurements were taken twice, with a third measurement if the difference between the first two exceeded 0.3 kg for weight and 0.5 cm for height. We calculated BMI z-scores according to World Health Organization standards and classified obesity as ≥ 2 SD and not-obese as < 2 SD. Participants were asked about their physical activity using a questionnaire that asked about total sedentary time, sports activity, walking to/from school, and scheduled and unscheduled exercise during and after school [3]. Scores ranged from 0 to 10, with higher numbers representing greater physical activity.

Participant eating behavior was assessed with an EAH paradigm beginning with an ad lib meal. The entire EAH protocol was pilot tested with Chilean adolescents. Pilot participants indicated that the questions translated into Spanish were understandable and also provided feedback on types of foods to offer. Participants were given a tray that included: juice, a fruit cup, either a ham and cheese or butter and jam sandwich (participant choice), flavored milk, and tea or coffee (sweetened with sugar based on participant request). Participants were accompanied by the same research physician who measured anthropometry. No other persons were present during the breakfast. Participants were not required to eat, but all did so. When the participant reported being done with the meal the researcher verbally confirmed that the participant did not want any more food and was not hungry. Participants were allowed to ask for additional food. Calorie and nutritional composition of intake (fat, protein,

carbohydrate and salt) was determined by trained nutrition staff after the meal based on manufacturer labels.

Twenty minutes after the breakfast, participants reported satisfaction and perceived ability to eat more food on a visual-analog scale used in previous EAH studies [10, 22]. The scale asks: (1) How hungry do you feel? (2) How satisfied do you feel? (3) How full do you feel? (4) How much do you think you could eat? (5) Would you like to eat something sweet? (6) Would you like to eat something salty? (7) Would you like to eat something "tasty"? (8) Would you like to eat something "fatty"? We also added five questions regarding satisfaction with the breakfast: (1) How did the breakfast look? (2) Smell? (3) Taste? (4) Taste in my mouth after the meal? (5) How tasty was the meal? Below each question was a 10 cm scale, with opposing choices anchored at each end (e.g. 0 = "not hungry at all" and 10 = "I have never felt hungrier"; 0 = "bad" and 10 = "good"). In its original form, visual-analog scale question #7 asks about eating "savory" food [18]. We were unable to identify a suitable Spanish translation to "savory" and thus modified this question to ask about wanting to eat something "tasty". The scale was completed along with several other non-appetite focused questionnaires (e.g., neighborhood safety and physical activity questionnaires) in order to better disguise the purpose of the scale.

After completing these questionnaires, participants proceeded to a room with freely available snacks: potato chips, peanuts, soft-drinks, ice-cream, candy, crackers, cookies, and chocolate. Alternative activities were also available: comics, teen magazines, and music. A research staff member was in the room and told the participants they had a brief break before finishing the evaluation and were free to eat or not eat if they liked. Twenty minutes later another team member escorted the participants out of the room. Snacks were weighed before and after the EAH experiment and a trained nutritionist determined energy and compositional intake based on manufacturer labels. Participants had access to their cell phones during both meal times.

Analysis

Only adolescents who reported not being hungry after breakfast—reporting levels of hunger < 3.5 on the visual-analog scale—were included in data analysis (n = 605) [22]. Caloric intake and responses to the visual-analog scale were non-normally distributed, thus we described all variables as either a frequency or median and inter-quartile range. In the entire sample (males and females combined), we tested the overall association between obesity and eating behavior. We had three primary outcomes: whether adolescents ate anything at the EAH snack, whether adolescents ate above the median total calories (sum of calories consumed at preload meal and EAH snack), and among those who ate at the EAH snack, whether they ate higher than the median calories at the EAH snack.

We used binary logistic regression to test whether obesity related to eating behavior. All models were adjusted for sex and, because of our previous work, breastfeeding [29]. Breastfeeding information had been collected prospectively in infancy between 4 and 12 months [25]. Information was coded as "0" if infants were breastfed as the sole source of milk for < 6 months and "1" if 6 months or greater. In all models (overall and stratified by sex), we tested if the following variables influenced the relationship between obesity and EAH behavior: infancy iron status (iron deficiency anemia yes/no), calories consumed at breakfast meal (not included in the total calories model), reported usual breakfast consumption, physical activity score and maternal education. The covariates were not significantly related to the outcomes in any model and thus removed for parsimony. Because of the previously reported sex and obesity interaction with response to EAH [7, 16, 21, 22], we tested a sex by obesity interaction term in all models. SPSS version 24 was used for all analyses and $p < 0.05$ determined statistical significance.

Results

Participants were 16.8 years old and 51% male. Descriptive statistics of eating behavior and response to the visual-analog scale are provided in Table 1. Median breakfast kcal consumption was 602 (IQR 474–746). Participants reported enjoying the breakfast meal, with median values between 9.5 and 10 for questions about the look, smell, taste and satisfaction with the meal (data not shown). Participants also reported high fullness after breakfast, but endorsed the possibility of eating more (see Table 1).

Overall, participants reported low desire to eat something sweet, salty, or fatty, with slightly higher reported desire to eat something tasty. Snack was consumed by 47% of the overall sample (n = 287); 49.6% of adolescents without obesity ate something at snack compared to 35.3% of participants with obesity. Among those who ate snack, 155 additional calories were consumed (IQR 78–283); 52.1% of adolescents without obesity who ate snack ate above the median number of EAH calories compared to 36.7% of adolescents with obesity. Figure 1 shows breakfast, EAH (among those who ate), and total calorie consumption by obesity status. As seen in the figure, participants with and without obesity ate similar number of median calories, but the range was larger for participants without obesity.

Eating Behavior and Obesity Status

We observed a protective effect of obesity for eating anything at the EAH snack. Overall, adolescents with obesity

Table 1 Characteristics of the overall sample, eating behavior and response to visual analogue scale (n = 605)

	Missing	% (n)/median (IQR)
Male	0	51.6% (312)
Maternal education (years)	0	10 (4)
Breastfed < 6 months	4	72.7% (437)
Infancy iron deficiency anemia	0	17.7% (107)
Age	0	16.7 (0.4)
Physical activity score	0	4.0 (2)
BMI z-score[a]	0	0.6 (1.5)
Obesity	0	14% (85)
Usually eats breakfast[b]	1	78.7% (475)
Preload energy intake (kcal)	5	611 (268)
Visual analogue scale		
How hungry do you feel?[c]	0	0.4 (0.8)
How satisfied do you feel?[d]	0	8.6 (2.5)
How full do you feel[e]	3	8.6 (2.6)
How much do you think you can eat?[f]	0	4.4 (5.3)
Would you like to eat something sweet?[g]	0	1.7 (5.1)
Would you like to eat something salty?[g]	0	1.4 (4.7)
Would you like to eat something tasty?[g]	1	3.6 (5.6)
Would you like to eat something fatty?[g]	0	0.5 (2.4)
EAH behavior		
Ate EAH snack	2	47.6% (287)
Snack energy intake (kcal)[h]	2	155 (196)
Total kcal consumed	4	676 (316)

EAH eating in the absence of hunger

[a]BMI z-score ≥ 2 SD according to World Health Organization standards

[b]Includes persons reporting "YES" and "SOMETIMES"

[c]0 = "not hungry at all", 10 = "never been more hungry"

[d]0 = "completely empty", 10 = "cannot eat another bite"

[e]0 = "not at all full", 10 = "totally full"

[f]0 = "nothing at all", 10 = "a lot"

[g]0 = "not at all", 10 = "very much"

[h]Among those who ate EAH snack (n = 287)

had a 0.61 (95% CI 0.37–0.99) reduced odds of eating at the EAH snack. For adolescents who ate the EAH snack, we did not observe a relationship between obesity and eating above the median number of EAH calories. Eating above the median number of total calories was significantly related to obesity status. Adolescents with obesity had a 0.59 (95% CI 0.36–0.96) reduced odds of eating above the median total calories, compared to adolescents without (see Table 2). An obesity by sex interaction was not statistically significant in any of the tested models.

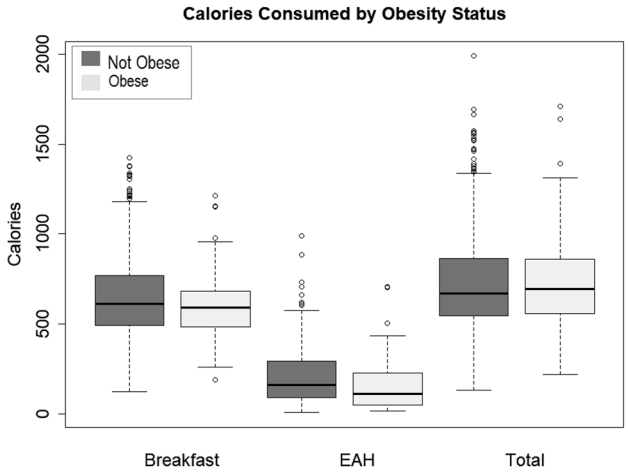

Fig. 1 Calories consumed by obesity status

Table 2 Logistic regression testing relationship between EAH, overall eating behavior and obesity

	Overall
Ate EAH snack	0.61 (0.37–0.99)*
Ate above median kcal at EAH snack	0.58 (0.26–1.54)
Ate above median total kcal	0.59 (0.36–0.96)*

All models adjust for sex and breastfeeding

*p < 0.05

Discussion

Contrary to our original hypothesis, we found that adolescents with obesity were less likely to eat additional calories at the EAH snack and ate fewer calories overall (total calories from preload meal and EAH snack) compared to adolescents without obesity. While we tested for an interaction between sex and obesity, we were unable to conclude that the relationship between eating behavior and obesity varied by sex.

There are at least two possible explanations for our finding that adolescents without obesity ate more than their counterparts with obesity. First, participants with obesity, in general, may be more concerned about their weight and likely to restrict their eating behavior. This may be especially true in the particular context of this study, where participants were assessed at a known nutrition institute. Despite our efforts to offer only unbiased instructions on eating and describe the overall purpose of the study in general terms, some participants may have suspected their eating behavior was being monitored and altered their behavior in response. Second, we considered that physical activity may have played a role in consumption, as

non-obese participants may be more physically active than obese adolescents. However, in initial models we adjusted for physical activity assessed via questionnaire and did not find a relationship with eating behavior. We acknowledge that physical activity reported via questionnaire may be biased [5, 31]. Thus, it is possible that objectively-measured physical activity, would have found that the differences in caloric consumption were associated with physical activity.

Our EAH study did not require any minimum food intake. In other EAH studies conducted with school-age children and adolescents, participants are asked to taste all EAH snack food and rate their preferences for each food, after which they are free to continue eating snack foods ad libitum [8, 21, 22, 32]. This small intervention may represent a move away from unbiased exposure, thus activating brain reward centers and explaining why in at least some of these studies a positive relationship is found between BMI and EAH consumption [7, 9, 32]. In related work, a study by Frankort et al. assessed functional magnetic resonance imaging (fMRI) with normal and overweight adult women and found that when presented with food stimuli without any further instructions (unbiased exposure), neural reward centers in the brain reacted with lower frequency among overweight compared to normal weight participants [12]. However, when participants were asked to imagine the taste of the food stimuli, reward center response was higher among overweight participants. Differences were noted for only high energy, highly palatable food stimuli (e.g. ice-cream, chocolate). The findings of the Frankort study suggest that overweight participants may be more sensitized to restrict eating when exposed to an obesogenic environment, a personality trait that normal weight adult women may not have. Our EAH snack may be interpreted as an unbiased exposure to food stimuli, as no instructions were given to encourage participants to reflect on a response to the food (i.e. consider how much they enjoy a particular appetizing food). Thus, similar to the fMRI study and at least one other previous EAH study [22], people with obesity, compared to those without, in this Chilean sample of adolescents may have been better able to resist simple temptation to highly palatable treats because they had not been asked to imagine or actually taste the snack first. As a whole, the current results suggested that the mere presence of highly palatable foods is not enough to overeat, but, rather, the environmental context that accompanies food may also be important. Individuals sensitive to food pleasure may be more vulnerable to overeating/EAH given current food marketing techniques, where much marketing advertises food as being "delicious" and "impossible to resist".

Our results must be interpreted considering several limitations. Many EAH studies are conducted after a lunch or dinner preload, however, because of the need to obtain a fasting blood sample on the same visit, we opted for exposure to EAH after a standard breakfast. Clearly, there may be a difference in the circadian rhythms of eating when comparing levels of hunger or ability to eat more in the morning as opposed to the afternoon or evening. In our previous work, we showed that self-reported regular consumption of breakfast did not relate to amount consumed in the experimental setting [29]. However, future studies would benefit from a 24-h recall of regular food consumption to compare how the preload meal differed in timing and calorie or macronutrient content from regular meals. As this analysis is cross-sectional, we cannot make conclusions regarding how current snacking may relate to future risk of obesity. Additionally, as we previously discussed [29], social desirability may have influenced consumption as participants ate breakfast and snack after being weighed and measured. Some may argue that how adolescents reacted to this EAH experiment may not reflect actual behavior outside of this controlled, experimental setting. However, even in low- and middle-income homes of urban Santiago, Chile, changes in the global food market have made energy dense, highly palatable junk foods easily obtainable. An obesogenic environment is increasingly the norm for many adolescents across the world, including Chileans. There are also notable strengths of this study. Our study of Chilean adolescents is one of the largest EAH studies to date and one of the few to have been conducted outside of the US. Additionally, it is the only study, to our knowledge, of EAH to use a breakfast meal as the pre-load.

Conclusions

Despite the fact that many published articles demonstrate a positive relationship between adiposity and EAH behavior [7, 9, 21, 22, 27, 32], we observed the opposite. Most studies that have shown this relationship have been conducted with younger samples (toddlers and primary-school children). The exceptions are a study of Shomaker et al. whose sample was, on average, 1.5 years younger than ours [32] and Kral et al. who studied 13 year-olds [22]. Thus, the difference may be explained, in part by age, as our participants were nearly 17 years old. We recommend additional studies in older adolescents. Furthermore, our administration of the EAH paradigm was different from most other studies that require at least some EAH intake via food tasting at the start of the experiment. We do not know how important initial taste testing of foods is in potentiating EAH behavior. Additional studies comparing EAH with and without initial taste testing could enhance understanding of these complex relationships.

Author Contributions SG, RB and MR designed the study and wrote the protocol. EB designed and conducted the statistical analysis, conducted literature searches and wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

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Compliance with Ethical Standards

Conflict of interest The authors declare they have no conflict of interests.

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