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Understanding eating in the absence of hunger among young children: A systematic review of existing studies

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Abstract

Background—Eating in the Absence of Hunger (EAH), or consuming highly palatable foods when satiated, is one behavioral pathway that may lead to childhood obesity. EAH is an objective, laboratory-based measure. A more comprehensive understanding of potential determinants of EAH could inform childhood obesity programs outside of a laboratory setting.

Objective—Systematic review of EAH experiments to identify individual, familial, and societal-level correlates of EAH among children 12 years of age or younger.

Design—1,487 studies were retrieved from five electronic databases (Medline [PubMed], Web of Science, Cochrane Library, CINAHL, PsycINFO). Eligible studies were those that measured EAH as initially operationalized in a laboratory setting enrolling children ≤12 years or reporting age-specific results for children ≤12 years. Only articles written in English were included.

Results—12 cross-sectional, six prospective, and one behavioral-intervention studies were included in the review. EAH was observable among boys and girls; absolute levels of EAH increased with age; and maternal feeding styles were associated with EAH among girls. The most consistent evidence supported increased levels of EAH among overweight and obese versus normal weight children, both cross-sectionally and prospectively. Two studies supported a genetic component to EAH.

Conclusions—Studies enrolling independent samples support a positive association between weight status and EAH among children; studies addressing causality are needed. Other various individual, genetic, and familiar characteristics were associated with EAH, yet studies among more heterogeneous sample populations are needed to confirm findings. Studies addressing societal-level factors related to EAH were absent.

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INTRODUCTION

U.S. prevalence of childhood obesity has tripled from 1970 (1), and currently in the U.S., 32% of children and adolescents are overweight or obese (2). Childhood overweight and obesity is positively associated with health risks during childhood, such as the development of metabolic syndrome and the presence of cardiovascular disease risk factors (3–5), as well as longer-term health consequences such as obesity during adulthood and obesity-related morbidities (6, 7). In the current obesogenic environments of many developed countries, (8, 9) there are a multitude of cues and opportunities to consume energy-dense, nutrient-poor foods such as sugar-sweetened beverages, snack foods, and fast foods. As eating in the absence of hunger (EAH), or eating palatable foods past the point of satiety (10), is one potential behavioral pathway to childhood obesity, understanding who is most susceptible to external cues that may trigger EAH could better tailor behavioral interventions to prevent and treat childhood overweight and obesity (11).

Fisher and Birch (10) first coined the term EAH to explore children's post-meal intake of snack foods when snacks were made freely available. In a laboratory setting, Fisher and Birch first fed an ad-libitum meal to children until they self-reported that they were full (preload phase), and then provided children an opportunity to eat snacks while playing with toys for 10 minutes without adult supervision (free access phase). The snacks were weighed before and after the free access phase, and each child's caloric intake from these foods was computed. EAH was then operationalized as the number of kilocalories consumed during the free access phase. Thus, EAH serves as a valuable behavioral index of children's dietary disinhibition that may contribute to excess weight gain (12).

EAH is an operationalized metric that can be easily replicated in laboratory settings (12), and several studies have reported positive associations between EAH and adiposity among children (16–26). EAH is observable at all ages in childhood through the preadolescent years (16, 21), and can be reliably measured as early as 3 years of age (12, 20). Although child-report (13) as well as parent-report (14) questionnaire measures of eating beyond satiation have been developed and used in studies with children, the laboratory-based EAH paradigm (referred to as "EAH studies" from hereon) is considered the gold standard (15). Two previous reviews (15, 27) have included some of the existing EAH studies in the context of genetics (15) and eating behaviors related to energy intake (27); however, there has been no comprehensive and systematic review of EAH studies to date.

Thus, this article presents a comprehensive and systematic review of EAH studies with children to better understand correlates of EAH based on a multi-faceted model of eating behavior that takes into account genetic, physiological, psychological, behavioral, familial, and larger social influences. The current study is unique in that we exclusively review studies that follow a laboratory-based EAH protocol, which is considered to be the gold standard. In areas of the multi-level model of eating behavior where research is lacking, we clearly identify gaps. A more comprehensive understanding of the etiology of children's EAH behavior from the most rigorous laboratory-based studies could help inform obesity prevention programs at the individual, familial, and societal levels.

METHODS

Literature Search Strategy

We conducted a comprehensive literature search during January and February 2013 employing a wide range of electronic databases, lateral search techniques, and consultation with experts. On January 7, 2013, we searched Medline (PubMed), Web of Science, Cochrane Library, CINAHL, PsycINFO. The following combination of keywords were used to indicate the act of eating when satiated, state of fullness, or response to satiety: eating without hunger, eating when full, eating when satiated, eating beyond fullness, eating beyond satiety, eating [within 5 adjacent words] not hungry, snacks [and] (meal [or] lunch) [and] immediately following, and satiety responsiveness. A total of 123 articles, with duplicates removed, were retrieved.

Eligibility Criteria

Studies following the EAH feeding paradigm as defined by Fisher and Birch (10) were eligible for inclusion; studies based on self-reported EAH were excluded. Studies in which the preload was a snack or a drink and not a meal fed *ad libitum* were excluded. We included studies that operationalized EAH as the absolute number of kilocalories (kcals) of palatable foods consumed during the free access phase in the absence of hunger, and also included studies that operationalized EAH as the weight (grams) of palatable foods consumed. EAH has been reliably observed in children as young as 3 years old (10, 19, 28); however, the eating behaviors of adolescents may be qualitatively different from that of younger children due to physical maturation, hormonal changes, increased autonomy in food-related decision making, and other social factors such as peer pressure and dieting (29). Therefore, we limited this review to studies that only enrolled children ≤12 years, or to those that reported age-specific analyses for preadolescents. Other inclusion criteria were that the article was published in a scientific peer-reviewed journal and that the article was written in English.

The title, abstract, and full text of the 123 potentially eligible articles were screened for the inclusion criteria of this current review, which resulted in a final pool of 15 eligible studies. A relevant author search rendered one additional eligible article. The citations of the 16 identified articles (1,093 citations, including duplicates) were then screened, rendering three additional articles qualifying for review. Lastly, all articles that cited one of the 19 eligible studies identified (1,478 articles, including duplicates) were screened for potential inclusion, and no additional articles met the eligibility criteria. Two independent readers verified the eligibility of the selected articles, and there were no disagreements regarding eligibility. Thus, this review included a total of 19 eligible studies.

Data Extraction

Data was abstracted from the included studies by one author (R.K.L.) and reviewed by the other authors (J.A.E. & D.G.D.). Variables included in this review included those hypothesized as being associated with EAH as stated in at least one of the included studies. We additionally considered understudied factors that may relate to EAH among children, based on the knowledge of the research team.

RESULTS

Tables 1 and 2 present sample characteristics, study design, child and parent measures, and a synopsis of the primary findings for the 19 reviewed studies, by study design. The 19 studies include 12 cross-sectional, six prospective cohort, and one behavioral intervention studies, reflecting 11 independent sample populations. The majority (N=15) of studies operationalized EAH as the total amount of kcals consumed, (10, 16–20, 22–26, 30–34) while three studies operationalized EAH as the weight (grams) of palatable food consumed (28, 35, 36). The one behavioral intervention study (31) operationalized EAH as the excess proportion of required energy intake according to age, weight, height, and physical activity level. While that outcome does not meet the original EAH criteria as operationalized by Fisher and Birch (10), that study was included in this review as it was the only study assessing behavioral treatment of EAH that was identified. Table 3 presents an outline of findings from this review as discussed below.

Individual Characteristics Related to EAH

Children's Weight Status—In cross-sectional studies, EAH was positively associated with child's adiposity when reported as weight-for-height (19), weight-for-height z-scores (30), or overweight status (BMI ≥95th percentile (20), BMI age and gender adjusted z-scores >85th percentile (23, 24), or categorized age- and gender-adjusted BMI standard deviation scores (26) among girls (19, 20, 23, 30) and boys (20, 23, 24, 26). Notably, two studies (24, 26) reported an inverse association in that overweight girls engaged in less EAH compared to their normal-weight peers. Both of those studies enrolled older children (ages 7 to 9 or 13), and one took place in the child's home while the child was being videotaped (24), and the other took place in a school setting (26). Thus, it is possible that overweight preadolescent girls may restrain from EAH in settings where peers are observing them.

Prospective studies support a positive association between excess weight and EAH. From Fisher et al.'s series of prospective studies based on a cohort of 197 parent-daughter dyads (16, 17, 22, 25, 34), greater weight was positively associated with greater EAH over time among girls. Butte et al. (2007) similarly reported positive associations between weight gain and EAH over a one-year period among 879 Hispanic boys and girls (18). More research is needed to determine causality between a child's weight status and EAH, as well as the impact of eating location and setting on EAH particularly among girls.

Children's Age—Most of the cross-sectional studies (8 out of 12) enrolled children between 3–6 years (10, 19, 28, 30, 32, 33, 35, 36), while four (20, 23, 24, 26) included older children, up to age 18 (20). No study specifically compared EAH across age categories; however, all studies reported EAH, suggesting that EAH occurs in children as young as 3 (10, 19, 28). One cross-sectional study of 801 Hispanic children, aged 5–18 years (20), reported that EAH was significantly greater among older children compared to 5 year olds, and it leveled off at age 13. In a series of prospective studies based on the original cohort of 197 mother-daughter dyads sampled by Fisher, Birch, and Francis (16, 17, 21, 22, 25, 34), the absolute levels of the girls' EAH girls increased from age 5 to age 13. Authors also observed several characteristics that modified the rate of change in EAH over time, as

described below. Therefore, EAH is likely present among children as young as 3 and likely increases with age, at least until age 13. However, the association between EAH with respect to age-adjusted, daily caloric needs remains understudied.

Children's Gender—Ten of the 12 cross-sectional studies enrolled both boys and girls (10, 19, 20, 23, 24, 26, 28, 32, 35, 36), and EAH was observed in both genders. However, gender was found to modify the associations between other correlates of a child's EAH including child's weight status (19, 24, 26), parental characteristics such as restrictive feeding practices (10, 30, 33) or mother's level of dietary disinhibition (19) across three independent sample populations. Specific results related to modification by gender are discussed under the other correlates below.

Child's Race/Ethnicity—Of the 12 cross-sectional studies, five (10, 19, 30, 32, 33) were based on the same cohort of predominantly white, non-Hispanic children from the U.S. One cross-sectional study (20) enrolled Hispanic girls only, and one (23) enrolled a racially diverse sample of boys and girls, predominately (68%) African-American. The remaining studies enrolled predominately white participants (26, 28), an ethnically diverse sample (26), or did not report on race or ethnicity (24, 35, 36). EAH was observed across all of those independent samples. For example, Kral et al. (23) enrolled a racially diverse sample of boys and girls (68% African-American; 20% Hispanic), and in that study, overweight and obese siblings consumed 34% more kcals during EAH than their normal-weight siblings ($p=0.006$) (23); findings which were consistent with other cross-sectional studies that also demonstrated higher levels of EAH among overweight children compared to normal-weight children among predominantly white girls (19), white boys (26), and Hispanic girls and boys (20). Regarding prospective studies, while six out of the seven studies were based on a cohort of predominately white girls (16, 17, 21, 22, 25, 34), one enrolled Hispanic boys and girls (18), and similarly to the cross-sectional findings, that latter study also reported higher levels of EAH among the overweight children compared to the normal-weight children (18). Thus, the consistent association of greater levels of EAH among overweight children compared to normal-weight peers across these various studies is that EAH is present among children across diverse racial and ethnic backgrounds. Notably, studies directly comparing EAH by race and ethnicity are absent, as are studies to assess how race or ethnicity may modify the association of other characteristics with respect to EAH.

Children's Eating Style—Eating style refers to one's own behaviors and intentions when eating (37, 38). For example, the Dutch Eating Behaviour Questionnaire (34) is one measure of eating style that incudes three domains related to restrained, emotional, and external eating, with items assessing such factors as level of restraint when eating because of concerns about weight, eating in response to emotional states such as boredom or sadness, and responsiveness to external and internal cues of hunger and satiety (37, 38). Moens & Braet (2007) (24) investigated the impact of children's eating style as measured with the Dutch Eating Behaviour Questionnaire on EAH among 52, 7–13-year-old-boys and girls in Belgium. In their study, a significant positive association was reported between a composite score of eating in response to emotional and external cues to EAH when EAH was categorized as a binary variable (eating any palatable snack foods versus none). No other

study included in this review reported on child's eating style with respect to EAH. Thus, children's eating style remains an unexplored domain that may influence EAH.

Children's Affect—In an effort to determine the effect of emotional state on EAH among children, Blissett et al. (28) conducted a small study (n=25) in which children were exposed to a negative mood condition (being asked to complete a jigsaw puzzle with a missing piece) or control condition (complete puzzle) before the EAH phase of a laboratory experiment where children were presented with six different foods: potato chips, chocolate-chip cookies, chocolate candy, green grapes, carrot sticks, and mini breadsticks. Total levels of EAH did not significantly differ between treatment conditions; however, among children of parents who rarely used food to regulate their child's emotions, the authors reported a significantly greater amount of chocolate eaten by children in the control condition compared to children in the negative mood condition. No significant differences were found in EAH for any of the food groups among children whose parents did frequently use food to regulate their child's emotions (24). Results are limited by the small sample size and the inconsistent findings across the various energy-dense food groups offered to the children. Thus, the impact of a child's emotional state on EAH remains largely understudied.

Children's Genotype—Variants in the fat mass and obesity-associated (*FTO*) gene are associated with BMI, obesity risk, and type 2 diabetes (39–44), and it is possible that a decreased ability to self-regulate food intake may partially mediate that association. Indeed, Fisher et al. (20) reported significant heritability for EAH among n=801 children aged 5–18 years from 300 Hispanic families; heritability for EAH was measured as the proportion of total phenotypic variance due to an additive genetic component. In a separate study, Wardle et al. (36) genotyped the FTO single nucleotide polymorphism rs9939609 among a sample of n=131 children aged 4–5 years in the U.K. to test the association between variants in the FTO gene and EAH. Authors observed a significant difference in EAH across the different genotypes (AA, AT, and TT). Specifically, children with the genotype AA or AT consumed significantly more food during the free access period (40.0 grams and 37.9 grams, respectively) compared to children with the TT genotype (30.0 grams; $p<0.032$). However, the percentage of participants who were overweight or obese was not significantly different by genotype. Thus, it is likely that the propensity to engage in EAH has a genetic component that is observable in children as young as 4, before excess weight gain occurs. Studies are needed to further explore any associations between genetics, EAH, and weight gain as children age.

Familial Characteristics Related to EAH

Eight of the 12 cross-sectional and five of the six prospective studies included specific research questions assessing associations between parental characteristics and the child's EAH. To note, all of the studies that reported on parental characteristics as related to EAH enrolled children from predominately white, middle-class families in the US (10, 16, 17, 19, 21, 22, 30, 32–34), Belgium (24), or the UK (28, 35). Further, all of those studies that enrolled children in the U.S. (10, 16, 17, 19, 21, 22, 30, 32–34) enrolled children who lived with both biological parents. Thus, the generalizability regarding parental and even socioeconomic characteristics as related to EAH is limited.

Parental Adiposity—Two cross-sectional studies reported on associations between parental weight status and children's EAH (35). Faith et al. (32) retrospectively collected mothers' pre-pregnancy weight, and enrolled n=52, 5-year-old children based on a high or low risk for obesity (e.g., mothers' pre-pregnancy weight >66th percentile versus <33rd percentile, respectively). Boys who were at high risk of obesity weighed more and consumed twice as many calories during the EAH experiment compared to boys at low risk for obesity (32). No associations between mothers' pre-pregnancy weight and the EAH among girls were noted. Conversely, a larger study by Wardle et al. (35) did not find any significant associations between parental weight status (normal weight versus obese) and EAH among n=428, 4–5-year-old girls and boys; parental weight was measured when the enrolled child was 3 years old. That study did not assess any interactions by parental gender (35).

Francis et al. (19) reported a prospective association between mothers' weight status and daughters' EAH among n=171 mother-daughter dyads included as part of a larger study of n=197 parent-daughter dyads. The increase in EAH from age 5 to age 9 was significantly greater among daughters of overweight mothers compared to daughters of normal-weight mothers. Weight gain was also significantly greater among daughters of overweight mothers in that study (29). In addition, Francis et al. (29) further reported on EAH at age 13 among all n=197 dyads, and results demonstrated that girls with both parents overweight had larger increase in EAH and greater weight gain over time compared with girls with only one or no overweight parent (p=0.05). However, that same series of longitudinal analyses (22, 34) also indicated that maternal feeding styles might moderate such associations, as discussed next. Thus, to date, data regarding associations between parental weight status and a child's EAH are mixed, and suggest main effects may be moderated by other characteristics among households with an overweight parent.

Parental Gender—The initial EAH studies completed by Fisher & Birch et al. (10, 19, 30, 33) explored parental gender in the context of parental feeding styles and children's EAH behavior. Results from those studies demonstrated that maternal feeding style at the time when children were 5 years old, including restriction to highly palatable foods (16, 29), dietary disinhibition (10, 13, 14, 16, 19, 30), and dietary restraint (26), were positively associated with daughters' EAH cross-sectionally (10, 16) and prospectively (10, 19, 30, 33), while paternal feeding style was not associated with daughters' or sons' EAH (10, 16). Two other studies of independent samples explored the effect of parental feeding style on EAH (28, 21), and neither reported findings stratified by parental gender. While the findings from studies suggest that maternal feeding styles impact EAH among daughters, more studies are needed to assess the impact of paternal feeding styles on children's EAH, among both dual-parent and single-parent households. Importantly, more studies are needed to assess how parental gender may moderate potential associations between parental characteristics such as age, education, and employment status and children's EAH.

Paternal Disinhibited Eating Style—Another suggested correlate of children's EAH is parents' self-reported dietary disinhibition (19), commonly measured by the Eating Inventory Questionnaire (45). Dietary disinhibition, or dishinhibited eating style, refers to

the extent to which release from the cognitive control of eating occurs in response to cues, such as the presence of palatable foods and negative moods (45). Several researchers (27) have hypothesized that self-reported dietary disinhibition is positively correlated with EAH outside of a laboratory setting.

In a cross-sectional study of n=75 children aged 3–6 years old (19), a positive correlation was found between maternal, but not paternal, disinhibition and daughters' EAH (19); there were no associations between maternal and paternal disinhibition and EAH in sons. The authors concluded that children might learn to consume palatable foods in the absence of hunger through modeling the uninhibited eating behavior of their mothers, who generally tend to be the primary caretakers of children, and that girls may be more socially susceptible to modeling their mothers' behavior than boys (19). No other cross-sectional study reported on parental disinhibition and children's EAH. From the prospective studies of Fisher, Birch, & Francis et al. (16, 17, 21, 22, 25, 34), one (29) reported on parental disinhibition with respect to the child's EAH. That study reported on n=197 5-year-old girls and their parents who were followed up every two years until the girls reached age 13. When the girls were 5 years old, mothers who were overweight had significantly higher levels of self-reported dietary disinhibition compared to normal-weight mothers, and self-reported dietary disinhibition among mothers was positively correlated with daughters' EAH at ages 9, 11, and 13 (29). There were no significant associations between paternal dietary disinhibition and girls' EAH. Authors suggest that results support an additive model for the risk for overweight and obesity among girls from genetics, environmental characteristics, and learned dietary behaviors that may develop as girls reach adolescence (29). Data are limited. However, dietary disinhibition may be a learned behavior that contributes to EAH among girls as girls mature from early childhood to adolescence.

Paternal Feeding Restriction—The EAH paradigm was originally conceived of to test the influence that parental restriction of children's access to palatable foods has on the children's consumption of those foods when they were made freely available to them (10). As first hypothesized by Fisher and Birch (10), a parent's imposed restrictions on certain food groups may result in a child having diminished self-control when in the presence of such foods. Indeed, in a cross-sectional study of n=70 boys and girls, aged 3–6 years old, maternal self-reported restriction on palatable foods was positively associated with daughters' EAH (10). Maternal self-reported restriction was not associated with EAH among boys. Additionally, the child's self-reported perception of maternal restriction was positively correlated to maternal self-reported restriction among girls only, and self-reported perception of maternal restriction was positively associated with EAH among girls only. Finally, paternal self-reported restriction to palatable foods was not associated with EAH among girls or boys (10). Thus, results suggest that even as young as 3, girls are more aware of maternal restriction to palatable foods, which results in greater EAH in the unrestrained setting (10). A positive association between maternal restriction to palatable foods and daughters' EAH at age 5 was also observed in a larger cross-sectional study of n=197 girls (30, 33), and a non-significant, linear trend (p=0.06) was observed between parental (not specified as maternal or paternal) self-reported restriction and EAH among n=26, 5-year-old girls while in that same study, no association was reported among n=27, 5-year-old boys

(32). However, one cross-sectional study outside of the U.S. (24) among n=52, 7–13 year olds (69% girls) and another experimental study outside of the U.S. (28) among n=25, 3–5-year-old children (52% girls) did not find any significant associations between parental self-reported restriction and EAHs. Neither study assessed gender-specific effects. Prospective studies among that sample of n=197 parent-daughter dyads (16, 17, 21, 22, 25, 34) also indicated that higher levels of maternal restrictive feeding (n=171), measured when girls were 5 years old, positively predicted daughters' EAH at ages 7 and 9 (19). That association, however, was among dyads with overweight mothers only.

Taken together, maternal restrictiveness of palatable foods may impact daughters' EAH at an early age, possibly mediated by girls' awareness of maternal restriction. The impact of maternal restrictiveness at an early age on daughters' EAH may continue through early adolescence among families with overweight mothers, although such maternal restrictiveness at an early age is likely correlated with other genetic, environmental, and learned dietary behaviors that impact a daughter's dietary behaviors later in life (22, 34). Additionally, it is unclear how maternal restriction to palatable foods impacts daughters' EAH among more diverse populations than white, non-Hispanic, predominantly middle-class families in the U.S.

Additional Parental Feeding Styles—As noted above under *Child's Affect*, Blissett et al. (28) did not find a significant main effect of negative mood induction (being asked to complete a jigsaw puzzle with a missing piece) versus a control condition (complete puzzle) on EAH among 25, 3–5 year olds (52% female). There was only one significant interaction between treatment condition and maternal use of food to regulate their child's emotions reported: among children of parents who rarely used food to regulate their child's emotions, the authors reported a significantly greater amount of chocolate eaten by children in the control condition compared to children in the negative mood condition. There were no statistical differences in the amount of food children consumed by experimental condition among children whose parents frequently used food to regulate their child's emotions. Due to the small sample size and multiple sub-analyses, results must be interpreted cautiously. Finally, one cross-sectional study reported on two other parental feeding practices among n=52, 7–13 year olds (pressuring child to eat and monitoring food intake), neither of which was associated with EAH (24).

EAH Intervention

Standard treatment of EAH has not been established. Boutelle et al. (31) piloted two treatment methods on overweight and obese children who exhibited EAH behavior under an experimental condition. In the first treatment group (food cue exposure training), children underwent eight weekly sessions to build self-efficacy to avoid consuming food in the absence of physiological satiety when exposed to food cues. In the second treatment group (appetite awareness training), children were trained over eight weekly sessions to increase self-awareness of internal states of hunger and satiety and trained on how to monitor such sensations. Children in the second group were also taught coping skills to manage the urge to engage in EAH. Children in the food cue exposure training condition showed significant decreases in EAH immediately following the 8-week treatment and 6 months post-treatment,

while significant changes in EAH over 8 weeks or 6 months were not observed among children in the appetite awareness treatment (31). Experimental conditions were not compared against a true, non-treatment control group, and results are limited by the small sample size. However, results are promising that behavioral training based on building self-efficacy to control food cravings may reduce EAH among overweight and obese children.

DISCUSSION

In this comprehensive and systematic review of several cross-sectional and prospective EAH studies among children 3–12 years old, EAH was observable across all age groups and among both boys and girls. While the various studies examined different aspects of EAH ranging from individual characteristics of the child to characteristics of the child's parent, the most consistent evidence supported a positive association between increased weight status and EAH: overweight and obese children engaged in greater levels of EAH in cross-sectional studies, and increased weight status was positively correlated to levels of EAH over time in prospective studies. Adipose tissue is an active tissue that secretes various hormones related to energy maintenance (46) and it is possible that overweight or obese individuals engage in greater levels of EAH due to a hormonally based, diminished satiety response (46, 47). Conversely, EAH may be a behavioral trait that leads to overweight: for example, children do not completely compensate for excess calories consumed during EAH (23), which in turn is likely to lead to weight gain. Studies are needed to specifically address causality between EAH and weight status.

While EAH was observable among both boys and girls, findings suggested that external factors might have a greater impact on girls than boys with respect to EAH behaviors. For example, girls were more susceptible to maternal restriction to snack foods, which in turn related to a greater level of EAH among girls. Additionally, in two studies where girls were being observed by others, one conducted in a school setting (26) and one in a home setting where girls were being video-recorded (24), overweight girls engaged in less EAH than normal-weight girls did. Those findings were in contrast to most other laboratory studies where overweight children consumed more EAH than their normal-weight peers. Taken together, findings suggest that girls may be more aware of and sensitive to behavioral expectations regarding their dietary behaviors and thus, engage in greater levels of EAH in private based on an increased pressure to exert dietary restraint.

This review also reports on familial characteristics related to EAH among children. Parents who use food as a way to regulate their child's emotions may promote EAH among their children, and children of parents with a disinhibited eating style, a style marked by eating in response to external cues, were found to be more likely to engage in EAH. Those findings suggest that EAH may in part be a learned behavior. Such findings are useful for health professionals who can work with families to identify appropriate behavior modification strategies to reduce EAH among susceptible children. Indeed, the preliminary findings from Boutelle et al. (31)'s experiment are encouraging in that a behavior modification based on building self-efficacy to ignore external food cues may effectively reduce EAH among at risk children.

There is also evidence to support that EAH may have a genetic component based on two studies: one that used a family-based design and assessed the proportion of EAH due to heritability (17), and one that specifically compared EAH across variations in the *FTO* SNP rs9939609 (32). However, no study to date has considered familial characteristics and the genetic background of both child and parents simultaneously in an attempt to determine what proportion of EAH is learned and what proportion may be due to a shared genetic background.

Over this review, a number of limitations in EAH research have become apparent. One is the lack of uniformity in the operationalization of EAH. Fisher & Birch (10) originally conceived of EAH as the absolute number of kilocalories from palatable foods consumed during a free access phase in a laboratory setting. While we found that metric to be the most common (10, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 26, 28, 29, 30), other researchers computed EAH as the total mass of food consumed (24, 31, 32) and even as excess caloric intake with respect to the child's estimated energy expenditure or caloric requirements based on age, gender, and activity level (27). Additionally, there were many variations in setting for measuring EAH, as well as variations in the preload meals. Importantly, EAH is a laboratory measure, and the generalizability to a free-living setting has yet to be assessed. A consensus on how to best measure EAH both within and outside of a laboratory setting is needed for future studies to be consistent with respect to the generalizability of findings.

A validated EAH questionnaire for children has yet to be developed. Researchers have commonly utilized the Children's Eating Behaviour Questionnaire (CEBQ) developed by Wardle et al. (35) to extract constructs that may manifest as EAH among children, such as satiety responsiveness and emotional overeating. Tanofsky-Kraff (13) developed a self-reported questionnaire to assess the likelihood of EAH in children and adolescents 6–19 years old (EAH-C). That questionnaire reports on three domains of EAH including eating in response to negative affect, eating in response to external cues, and eating in response to fatigue or boredom. Values of internal consistency, convergent validity, and stability over time were all moderate to high among n=226 children and adolescents 6–19 years old (44), yet scores only differed by weight status (obese vs. non-obese participants) for the negative affect domain. The questionnaire is not yet validated against observed EAH, yet if high validity was to be found, the EAH-C would be a useful tool to screen for EAH behaviors on a larger scale than allowable in a laboratory setting.

A better understanding of how demographic and socioeconomic factors influence EAH is needed. For example, EAH was observed among samples of Non-Hispanic White, Non-Hispanic Black, and Hispanic children, yet more studies are needed to determine how cultural context may impact EAH among children. Additionally, studies are needed to determine how socioeconomic status may relate to EAH. There are also household characteristics that increase the likelihood of a child being overweight or obese, including a greater amount of time spent watching TV (48–51) the presence of a TV in the bedroom (49) and even fewer meals eaten together as a family per week (50). How such characteristics may relate to EAH remains unknown.

Finally, studies addressing the potential impact of a child's food environment from a societal perspective are absent. For example, in the U.S., a greater availability of energy-dense snack foods and beverages in neighborhood stores has been positively correlated to excess weight among children 6–7 years (49, 52) yet it is unclear how the availability of highly palatable foods within the community relates to a child's EAH. Further, exposure to food and beverage advertisements via television may mediate the positive associations between increased TV viewing time and child weight status (48–50, 53–55), yet studies examining the potential association between food and beverage promotions and EAH among children are absent.

Strengths of this study include the methodological search for EAH studies across multiple databases for peer-reviewed articles. Also, three researchers independently reviewed potentially eligible articles. The correlates we report on were those reported in at least one study included in this review, and thus, our approach identified evidence-based correlates of EAH among children. However, as a limitation to that method, our results do not address any specific theoretical model of behavior. The existing EAH studies are primarily focused on younger children, and we therefore cannot generalize findings towards older children or adolescents. As a further limitation, there were a limited number of studies enrolling independent study samples with a wide variation in the methodologies used across studies. Therefore, it is currently premature to create pooled effect sizes for each EAH correlate. Finally, as an additional limitation, only English-language articles were included in this review.

In summary, several individual and familial level characteristics, notably adiposity of the child and parent, impact and/or are impacted by EAH in young children. These findings can inform future studies designed to address our current limitations in understanding determinants of EAH in an effort to better tailor behavioral interventions to help curb child overweight.

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Abbreviations

EAH	eating in the absence of hunger
SNP	single nucleotide polymorphism
CEBQ	Children's Eating Behavior Questionnaire
BMI	body mass index
TEE	total energy expenditure

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HIGHLIGHTS

- Systematic review of laboratory-based eating in the absence of hunger (EAH) studies
- EAH observable among both boys and girls, but with some notable differences
- Positive cross-sectional and prospective association between weight status and EAH
- Absolute levels of EAH increase with age
- Review supports genetic component to EAH in children

Table 1

Characteristics and results of observational studies assessing eating in the absence of hunger among children 2–12 years old, presented by study design and chronological order of publication.[1]

Cross-sectional studies: Child EAH operationalized as the total kcals of snacks consumed					
Author, year	**Sample characteristics**	**Pre-load and ad-libitum meals**	**Child measures**	**Parental measures**	**Results**
Fisher & Birch 1999 (10)	• n = 71 • Age range: 3–5 yrs • Mean age: 5.0 ± 1.0 • Gender: 43% female • Ethnicity: predominantly white • Setting: daycare • Location: Philadelphia, PA, USA	• Pre-load: Usual lunch • Ad-libitum: 10 sweet and savory snack foods	• Gender • Perception of maternal restriction of children's access to palatable foods	• Maternal restriction of children's access to palatable foods	• For girls only, maternal restrictive feeding was positively correlated with both child perception of restriction and EAH
Cutting et al. 1999 (19)	• n = 75 • Age range: 3–6 yrs • Mean age: 4.8 ± 1.0 • Gender: 47% female • Ethnicity: predominantly white • Setting: daycare and laboratory • Location: Philadelphia, PA, USA	• Pre-load: Usual lunch • Ad-libitum: 10 sweet and savory snack foods	• Gender • Adiposity (weight-for-height) • Perception of maternal restriction of children's access to palatable foods	• Parental dietary disinhibition • Gender	• For girls only, adiposity was positively correlated with EAH • Maternal disinhibition was positively correlated with daughters' EAH
Birch & Fisher 2000 (30)	• n = 197[2] • Age range: 5 yrs • Gender: 100% female • Ethnicity: white only • Setting: laboratory	• Pre-load: Self-selected lunch • Ad-libitum: 10 sweet and savory snack foods	• Short-term caloric compensation in response to energy- density of foods • Maternal report of daughters' 24-hour dietary intake	• Maternal restriction of daughters' access to palatable foods • Maternal dietary restraint • Maternal perception of daughters' overweight risk	• Structural equation modeling techniques demonstrated that maternal dietary restraint and perceptions of daughters' overweight risk predicted maternal restrictive feeding, which in turn

Cross-sectional studies: Child EAH operationalized as the total kcals of snacks consumed					
Author, year	**Sample characteristics**	**Pre-load and ad-libitum meals**	**Child measures**	**Parental measures**	**Results**
	• Location: central PA (presumed), USA		• Adiposity (weight-for-height z-scores)		predicted daughters' EAH, lack of caloric compensation, maternal report of 24-hour dietary intake, and daughter's adiposity
Fisher & Birch 2000 (33)	• n = 197[2] • Age range: 5 yrs • Gender: 100% female • Ethnicity: unreported • Setting: laboratory (presumed) • Location: city unreported, USA	• Pre-load: Self-selected lunch • Ad-libitum: 10 sweet and savory snack foods	• Perception of parental restriction of daughters' access to palatable foods • Negative self-evaluation of engaging in EAH	• Parental restriction of daughters' access to palatable foods	• Parental restrictive feeding was positively correlated with daughters' EAH and daughter's negative self-evaluation of engaging in EAH
Faith et al. 2006 (32)	• n = 53 • Age range: 5 yrs • Gender: 49% female • Ethnicity: white only • Setting: laboratory • Location: PA, USA	• Pre-load: Self-selected dinner • Ad-libitum: 11 sweet and savory snack foods	• Gender • Adiposity (weight-for-height and weight-for-height z-scores)	• Parental restriction of children's access to palatable foods • Maternal prepregnancy weight status)	• Sons of mothers with higher prepregnancy weight status were more likely to be overweight and also engaged in more than twice as much EAH as sons of mothers with lower prepregnancy weight status • For daughters, there was a non-significant (p=0.06) linear trend of a positive association between EAH and parental restriction
Fisher et al. 2007 (20)	• n = 801 children from 300 familes[3] • Age range: 5–18 yrs • Mean age: 11.7 ± 0.2 • Gender: 49% female	• Pre-load: Self-selected dinner • Ad-libitum: 10 sweet and savory snack foods	• Gender • Age • Adiposity (BMI ≥95th percentile) • Fasting hormonal levels (ghrelin,	• None	• Overweight children's EAH was 14% higher than normal- weight children's

Cross-sectional studies: Child EAH operationalized as the total kcals of snacks consumed					
Author, year	**Sample characteristics**	**Pre-load and ad-libitum meals**	**Child measures**	**Parental measures**	**Results**
	• Ethnicity: Hispanic only • Setting: laboratory • Location: Houston, TX		amylin, insulin, leptin)		• EAH increased with age, leveling off at age 13 • Significant heritability was seen for EAH
Moens & Braet 2007 (24)	• n = 52 • Age range: 7–13 yrs • Mean age: 10.13 ± 1.62 • Gender: 69% female • Ethnicity: unreported • Setting: home • Location: Belgium (presumed)	• Pre-load: Usual family dinner • Ad-libitum: 10 sweet and savory snack foods	• Gender • Adiposity (BMI age and gender adjusted z-scores >85th percentile) • Eating style (external and emotional eating, restrained eating)	• Parental feeding (restriction, pressure to eat, monitoring)	• Overweight boys engaged in twice as much EAH as normal-weight boys • Significantly larger percentage of normal-weight girls engaged in EAH than overweight girls • Regardless of child's weight status, child's eating style was strongly associated with EAH • Parental feeding (including restriction) was not associated with EAH
Hill et al. 2008 (26)	Study 1: • n = 348 • Age range: 7–9 yrs • Mean age: 8.28 • Gender: 51% female • Ethnicity: diverse • Setting: school • Location: London, UK Study 2: • n = 316 • Mean age: 11.17 • Gender: 61% female	• Pre-load: Usual school lunch • Ad-libitum: 7 pre-wrapped sweet snacks	• Gender • Adiposity (age- and gender-adjusted BMI standard deviation scores)	• None	• In both studies, boys' EAH was positively associated with adiposity after adjusting for covariates • In study 1, there was a trend for girls' EAH to increase through underweight and healthy weight ranges and decline in heavier weight range in school setting

Cross-sectional studies: Child EAH operationalized as the total kcals of snacks consumed					
Author, year	**Sample characteristics**	**Pre-load and ad-libitum meals**	**Child measures**	**Parental measures**	**Results**
	• Ethnicity: predominantly white • Setting: home • Location: London, UK				
Kral et al. 2012 (23)	• n = 47 same-sex sibling pairs • Age range: 5–12 yrs • Mean age: 8.9 ± 2.3 • Gender: 53% female • Ethnicity: predominantly black and some Hispanic • Setting: • Laboratory • Location: unreported, USA	• Pre-load: Vanilla or chocolate pudding differing in energy density • Test meal: Standardized dinner • Ad-libitum: 6 sweet and savory snack foods	• Adiposity (BMI age and gender adjusted z-scores >85th percentile)	• None	• Overweight and obese siblings had 34% higher EAH than their normal-weight siblings

Cross-sectional studies: Child EAH operationalized as the weight of snacks consumed					
Author, year	**Sample characteristics**	**Pre-load and ad-libitum meals**	**Child measures**	**Parental measures**	**Results**
Wardle et al. 2001 (35)	• n = 428 • Age range: 4–5 yrs • Gender: 52% female • Ethnicity: unreported • Setting: home • Location: England and Wales, UK	• Pre-load: Usual lunch • Ad-libitum: 10 sweet and savory snack foods	• None	• Adiposity (parental weight status: normal weight/lean and overweight/ obese)	• No difference was found in child's EAH between parental weight status
Wardle et al. 2009 (36)	• n = 131 • Age range: 4–5 yrs • Gender: 68% female • Ethnicity: unreported	• Pre-load: Meal served at home • Ad-libitum: 3 popular varieties of biscuits	• Gender • Adiposity (BMI age and gender adjusted)	• None	• TT homozygotes engaged in significantly less EAH than AT heterozygotes or AA homozygotes, even after controlling for adiposity

Cross-sectional studies: Child EAH operationalized as the weight of snacks consumed					
Author, year	**Sample characteristics**	**Pre-load and ad-libitum meals**	**Child measures**	**Parental measures**	**Results**
	• Setting: laboratory • Location: UK		• Genotype of FTO single nucleotide polymorphism (SNP) rs9939609		
Blissett et al. 2010 (28)	• n = 25 • Age range: 3–5 yrs • Mean age: 4.4 • Gender: 52% female • Ethnicity: predominantly white • Setting: laboratory • Location: UK	• Pre-load: Standardized lunch • Ad-libitum: 6 sweet, savory, and healthy foods	• Assignment to negative mood induction or control condition	• Maternal restriction of children's access to palatable foods • Maternal use of food for regulation of children's emotions	• Regardless of experimental condition, children whose mothers often used food to regulate their child's emotions engaged in more EAH for chocolate cookies compared to children whose mothers did not use food to regulate their child's emotions • Children whose mothers infrequently used food to regulate their child's emotions engaged in more EAH for chocolate in the control condition vs. the negative mood induction condition, the only significant interaction between maternal feeding practices and experimental condition on child's EAH

Prospective cohort studies: Child EAH operationalized as the total kcals of snacks consumed					
Author, year	**Sample characteristics**	**Pre-load and ad-libitum meals**	**Child measures**	**Parental measures**	**Results**
Fisher & Birch 2002 (16)	• n = 192[2] • Age range: 5 yrs • Gender: 100% female • Ethnicity: white only • Setting: laboratory • Location: central PA, USA • Baseline and 2-year follow-up	• Pre-load: Standardized lunch • Ad-libitum: 10 sweet and savory snack foods	• Age • Adiposity (BMI age and gender adjusted z-scores >85th percentile)	• Parental restriction of daughters' access to palatable foods at baseline	• EAH showed stability from baseline to 2-year follow-up • Girls who engaged in more EAH at age 5 were 4.6 times more likely to be overweight at age 5 and two years later at age 7 • Parental restrictive feeding when girls were age 5 predicted daughters' EAH at age 7, even when daughters adiposity and EAH at age 5 were controlled for

Prospective cohort studies: Child EAH operationalized as the total kcals of snacks consumed					
Author, year	**Sample characteristics**	**Pre-load and ad-libitum meals**	**Child measures**	**Parental measures**	**Results**
Birch et al. 2003 (17)	• n = 140[2] • Age range: 5 yrs • Gender: 100% female • Ethnicity: white only • Setting: laboratory • Location: central PA, USA • Baseline, 2 and 4- year follow-up	• Pre-load: Standardized lunch • Ad-libitum: 10 sweet and savory snack foods	• Age • Adiposity (BMI age and gender adjusted z-scores >85th percentile)	• Maternal restriction of daughters' access to palatable foods	• EAH increased overall at 2- and 4-year follow-up • Maternal restrictive feeding when girls were age 5 positively correlated with daughters' EAH at 2- and 4-year follow-ups • Girls who were overweight at age 5 and received greater restriction had highest EAH at 4-year follow-up and the greatest increase in EAH from baseline to 4-year follow-up
Shunk & Birch 2004 (25)	• n = 153[2] • Age range: 5 yrs • Gender: 100% female • Ethnicity: white only • Setting: laboratory • Location: central PA, USA • Baseline, 2 and 4- year follow-up	• Pre-load: Self-selected lunch • Ad-libitum: 10 sweet and savory snack foods	• Age • Adiposity (BMI age and gender adjusted z-scores >85th percentile)	• None	• Girls' adiposity at age 5 was positively correlated with EAH at 2- and 4-year follow- ups • The rate of increase in EAH over time was greater among overweight girls than normal weight girls
Francis & Birch 2005 (22)	• n = 171[2] • Age range: 5 yrs • Gender: 100% female • Ethnicity: white only • Setting: laboratory • Location: central PA, USA • Baseline, 2 and 4- year follow-up	• Pre-load: Self-selected lunch • Ad-libitum: 10 sweet and savory snack foods	• Age • Adiposity (BMI age and gender adjusted z-scores >85th percentile)	• Maternal restriction of daughters' access to palatable foods • Adiposity (maternal weight status at baseline: normal weight and overweight)	• For overweight mothers, restrictive feeding at baseline was positively correlated with EAH at 2- and 4-year follow-up • For daughters of overweight mothers, EAH was positively associated with increase in adiposity from baseline to 2- and 4-year follow-ups • These relationships did not hold for daughters of normal-weight mothers
Francis et al. 2007 (34)	• n = 197[2] • Age range: 5 yrs • Gender: 100% female	• Pre-load: Self-selected lunch	• Age • Adiposity (BMI age and gender	• Incidence of overweight among both parents	• Girls' EAH increased over time • Girls with both parents overweight had highest EAH across all ages and highest

Prospective cohort studies: Child EAH operationalized as the total kcals of snacks consumed					
Author, year	**Sample characteristics**	**Pre-load and ad-libitum meals**	**Child measures**	**Parental measures**	**Results**
	• Ethnicity: white only • Setting: laboratory • Location: central PA, USA • Baseline, 2, 4, 6 and 8-year follow-up	• Ad-libitum: 10 sweet and savory snack foods	adjusted z-scores >85th percentile)	• Parental dietary disinhibition at baseline • Gender	increase in EAH over 8 years of follow-up • Level of maternal dietary disinhibition when girls were 5 was positively associated with daughters' EAH at ages 9, 11, and 13 • Paternal disinhibition was not associated with girls' EAH at baseline or at any follow-up visit
Butte et al. 2007 (18)	• n = 879 children from 319 familes[3] • Age range: 4–19 yrs (mean unreported) • Gender: 49% female • Ethnicity: Hispanic only • Setting: laboratory • Location: Houston, TX • Baseline and 1-year follow-up	• Pre-load: Standard dinner • Ad-libitum: 10 sweet and savory snack foods	• Gender • Age • Adiposity (BMI as age and gender adjusted z-scores >85th percentile) • Pubertal development • Sedentary activity • Dietary intake	• None	• EAH, dietary intake, and sedentary activity were higher in overweight children • Overweight children experienced greater weight gains over 1 year • Effects of EAH on weight gain over 1 year became non-significant once baseline adiposity, age, gender, and pubertal development were taken into account • Effects of EAH on weight gain non-significant in fully adjusted model

kcal: kilocalories; EAH: eating in the absence of hunger; RCT: randomized controlled trial;

[1] Results presented for 18 observational studies identified from a systematic review; 1 intervention study presented in Table 2.

[2] Authors have been contacted to verify that these are the same sample from different time points, 5–15 yrs.

[3] We were unable to verify whether these were different sample populations. Attempts were made to contact study authors.

Table 2

Characteristics and results of intervention study assessing eating in the absence of hunger among children 2–12 years old.

Behavioral intervention studies (N=1)				
Author, year	**Sample characteristics**	**Study design**	**Outcome**	**Results**
Boutelle et al. 2011 (31)	• High EAH children • n = 36 • Age range: 8–12 yrs • Mean age: 10.3 ± 1.3 • Gender: 58% female • Ethnicity: diverse • Setting: • Laboratory • Location: unreported, USA	• High EAH children assigned to 8 weeks of cue exposure treatment or appetite awareness training • Followed-up at end of treatment, 6 and 12 months post-treatment.	• Child EAH, operationalized as proportion of estimated energy requirements according to age, weight, height, and physical activity level	• Children in the food cue exposure treatment showed significant decreases in EAH post-treatment and 6 months post-treatment • Children in the appetite awareness training showed no change in EAH

kcal: kilocalories; EAH: eating in the absence of hunger; RCT: randomized controlled trial;

Table 3

Proposed correlates of EAH and strength of evidence of their link to EAH.[1,2]

Correlate	Association	Evidence[1]
Individual Level Characteristics of the Child		
Age	EAH is observable among children as young as 3 and likely increases with age at least until age 13.	++
	Understanding associations between EAH with respect to age-adjusted, daily caloric needs remains understudied.	−
Gender	EAH is observable among boys and girls.	++
	Gender modifies the associations of many determinants of EAH.	++ ++
Race	EAH is observable among Non-Hispanic White, Non- Hispanic Black, and Hispanic children.	++
	Studies assessing how culture may moderate EAH among children are absent.	−
Weight status	Children who are overweight engage in more EAH than their normal-weight counterparts.	++
	Studies addressing causality are absent.	−
Eating style	Children who eat in response to emotional and external cues engage in greater levels of EAH.	+
Affect	Children in negative mood states engage in more EAH.	+
Genetics	EAH is heritable.	++
Activity levels	Studies comparing a child's physical activity levels and sedentary behaviors to EAH are absent.	−
Familiar Level Characteristics of the Child		
Parental demographics	Studies assessing the impact of parental race and ethnicity, education, employment, household income, and even single vs. dual-parent households on EAH among children are absent.	−
Parental gender	Parental gender moderates association between parental feedings styles and EAH among children.	+
	Studies addressing parental gender with respect to other parental determinants of EAH are absent.	−
Parents' adiposity	Children of overweight parents engage in more EAH than children of normal-weight parents.	+
Parents' disinhibited eating style	Maternal dietary disinhibition is positively association with daughter's EAH.	++
Parents' feeding restriction	Maternal restrictiveness of palatable foods is positively associated with daughters' EAH.	+
Parents' use of food to regulate children's negative emotions	Children of parents who use food to regulate children's negative emotions engage in more EAH.	−
Availability of highly palatable foods in the home	Studies assessing the associations between the presence of and accessibility to highly palatable foods in the home on EAH are absent.	−
Societal Level Characteristics of the Child		
Availability of highly palatable foods in the community and at school/Exposure to food and beverage promotions	Studies assessing the impact of external cues related to consuming highly palatable foods are absent.	−

[1] Proposed correlates of EAH selected from factors reported as significantly associated with EAH among children from at least one study included in this review, and also includes other understudied factors that may relate to EAH among children.

[2] Strength of evidence supporting hypothesized associations defined as significant findings reported in more than one independent study sample (++), significant findings only among one study sample (+) or mixed findings reported among more than one independent study sample (+), and characteristics that are largely understudied (−).