



Comparison of the satiating properties of egg- versus cereal grain-based breakfasts for appetite and energy intake control in children[☆]



Tanja V.E. Kral^{a,b,*}, Annika L. Bannon^c, Jesse Chittams^a, René H. Moore^d

^a Department of Biobehavioral Health Sciences, University of Pennsylvania School of Nursing, Philadelphia, PA, United States

^b Department of Psychiatry, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, United States

^c University of Massachusetts Medical School, Worcester, MA, United States

^d Department of Biostatistics and Bioinformatics, Rollins School of Public Health, Emory University, Atlanta, GA, United States

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ABSTRACT

Background: Few studies exist that have systematically examined the role of protein, and egg protein in particular, in appetite and energy intake regulation in children.

Objective: The aim of this study was to compare the effects of three different types of breakfast on appetite and energy intake at subsequent meals in children.

Design: Forty children, ages 8–10, were served a compulsory breakfast (egg, cereal, or oatmeal) and lunch, consumed ad libitum, once a week for three weeks. Children's appetite ratings were assessed repeatedly throughout the morning. On each test day, caregivers completed food records, which captured children's intake for the remainder of the day.

Results: There was a significant main effect of breakfast condition on energy intake at lunch ($P = 0.02$) indicating that children consumed ~70 fewer calories at lunch following the egg breakfast (696 ± 53 kcal) compared to the cereal (767 ± 53 kcal) and oatmeal (765 ± 53 kcal) breakfasts. Calories consumed for the remainder of the day and daily energy intake did not differ across conditions ($P > 0.30$). There also were no significant differences in children's appetite ratings between conditions ($P > 0.43$).

Conclusions: Consuming an egg-based breakfast significantly reduced short-term, but not longer-term, energy intake in children in the absence of differences in appetite ratings.

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1. Introduction

Data from the National Health and Nutrition Examination Survey (2011–2012) indicate that 17% of youth between 2 and 19 years of age are obese (Ogden, Carroll, Kit, & Flegal, 2014). Given the lack of effective prevention and treatment tools, there is a pressing need to identify dietary strategies and foods that help promote satiety and moderate energy intake in at-risk children.

Eating breakfast, as opposed to skipping breakfast, has been associated with better appetite and energy intake control, better diet quality, and better weight control in children (Szajewska & Ruczynski, 2010). The macronutrient composition of breakfasts may also differentially affect satiety. Protein has been identified as the most satiating macronutrient, and studies have shown that consuming high-protein foods can decrease energy intake in adults (Weigle et al., 2005). Suggested

mechanisms by which egg-based proteins may affect satiety and food intake include the release of satiety hormones (e.g., glucagon-like peptide-1) (Geraedts, Troost, Fischer, Edens, & Saris, 2011) and changes in postprandial insulin response (Claessens, Calame, Siemensma, van Baak, & Saris, 2009).

Few studies have tested the effects of the protein content of meals, and breakfast in particular, on energy intake in children. In a pilot study with breakfast-skipping adolescents, the protein content of two breakfasts was modified by replacing a portion of the flour in pancakes with whey protein powder (Leidy & Racki, 2010). The findings from this pilot study showed that ingestion of a protein-enhanced, compared to a normal-protein breakfast, led to significantly greater decreases in appetite, but it did not affect perceived fullness in adolescents. Further, the protein-enhanced breakfast, compared to the normal-protein breakfast, led to significant reductions in energy intake at a subsequent ad libitum lunch, but it did not affect 24-hour energy intake. These data provide preliminary support for the notion that a protein-enhanced breakfast may benefit appetite and promote energy intake control in youth, but pediatric studies investigating possible satiety-enhancing effects of egg-protein are widely lacking to date. The systematic study of the effects of breakfast composition (e.g., macronutrient composition) on appetite and intake regulation is especially important for younger

Abbreviations: BMI, body mass index; VAS, visual analog scale.

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* Corresponding author at: University of Pennsylvania, School of Nursing and Perelman School of Medicine, Department of Biobehavioral Health Sciences, 308 Claire M. Fagin Hall, 418 Curie Blvd., Philadelphia, PA 19104-4217, United States.

E-mail address: tkral@nursing.upenn.edu (T.V.E. Kral).

children, such as elementary schoolchildren, as their dietary habits are still forming and the findings from these studies may also inform nutrition standards and meal requirements for school meals (e.g., School Breakfast Program).

The primary aim of this study was to compare the effects of three different types of breakfasts (eggs, oatmeal, or cereal) on energy intake at subsequent meals in children. We hypothesized that the egg breakfast would be the most satiating breakfast and would suppress energy intake in children at subsequent meals the most. A secondary aim was to test the effects of these three different types of breakfasts on children's appetite control. We hypothesized that the egg breakfast would lead to better appetite control (i.e., decreased hunger, enhanced fullness) in children compared to the cereal grain-based breakfasts.

2. Methods

2.1. Study design

This study used a crossover design with repeated measures. Children came to the Center for Weight and Eating Disorders (CWED) at the University of Pennsylvania to eat breakfast and lunch once a week for three consecutive weeks. All study visits were scheduled one week apart. On each test day, the same lunch was served, but the type of breakfast differed (i.e., eggs, oatmeal, cereal). Breakfasts, which had to be consumed in full, were matched for energy content, and were similar in energy density (kcal/g), volume, and palatability. The order of presenting the breakfast conditions was randomized. Lunch was consumed *ad libitum*. After the completion of each visit, caregivers were asked to keep food records to capture their children's food and beverage intake for the remainder of the day (away from the lab). Children rated perceived appetite sensations repeatedly throughout the morning using visual analog scales (VAS).

2.2. Participants and recruitment

Participants included 40 boys and girls, ages 8 to 10, and their primary caregiver. Children with a range in body weight (BMI-for-age > 5th percentile) were included to test if the dietary manipulation is equally effective in normal-weight and overweight/obese children. This specific age range was chosen because 8- to 10-year-old children are especially susceptible to inadequate breakfast intakes (Siega-Riz, Popkin, & Carson, 1998) and therefore may considerably benefit from the findings of this study. Only children who regularly ate breakfast were enrolled in the study to ensure that they were willing to consume the compulsory breakfast in full.

Families were recruited through newspaper/online advertisements and flyers distributed in local grocery stores/pharmacies and public transportation stations. Families from all races/ethnicities were eligible to participate in the study. To be included, children had to be: 8 to 10 years; BMI-for-age > 5th percentile; and like most foods that were served in the study (see *Taste preference assessment*). Children were excluded from participation if they had serious medical conditions or were taking medications (including ADHD medications) known to affect appetite, food intake, and/or body weight; any developmental, medical, or psychiatric conditions that may impact study compliance and procedures; any food allergies/intolerances (including allergies to egg protein and dairy); were not regular breakfast eaters; were on a special diet or were vegetarian; wore braces or were expected to receive braces over the study period; or were diagnosed with a learning disability or sight or hearing impairment.

The study was approved by the Institutional Review Board of the University of Pennsylvania. Caregivers and children were asked to provide voluntary consent (caregivers) and assent (children) to participate in the study by signing the consent and assent forms.

2.3. Assessment of child height and weight

At the screening visit, a trained staff member measured children's weight on a digital scale (Tanita BWB-800, Arlington Heights, IL; accurate to 0.1 kg) and their standing height on a stadiometer (Veder-Root, Elizabethtown, NC; accurate to 0.1 cm) with children wearing light clothing and having their shoes removed. Both measures were taken in duplicate; the mean was used for analyses. Child age- and sex-specific BMI percentiles and z-scores were calculated using the Center for Disease Control and Prevention Growth Charts 2000 (Ogden et al., 2002). Child weight status was defined as normal-weight for children with a BMI-for-age between the 5th and 84th percentile, overweight for children with a BMI-for-age between the 85th and 94th percentile, or as obese for children with a BMI-for-age greater or equal to the 95th percentile.

2.4. Taste preference assessment

At the screening visit, children's liking for all study foods and beverages was assessed using a taste preference assessment (Birch, 1980; Birch & Sullivan, 1991). First, children were asked to taste a bite-sized amount of each of the breakfast foods (i.e., eggs, oatmeal, cereal with milk, toast, pop tart, peaches) and rate each food using five cartoons ranging from a frowning to a smiling face (1 = 'dislike very much', 2 = 'dislike a little', 3 = 'just ok', 4 = 'like a little', 5 = 'like very much'). Children were asked to recall and verbally rate their liking of orange juice and milk without tasting them. Once children finished rating all foods, a rank-order preference assessment was performed for the breakfast entrées (eggs, oatmeal, cereal with milk) during which children were asked to indicate the most liked entrée, the next most liked entrée, etc. Children then repeated the taste preference assessment for the lunch foods (i.e., chicken nuggets, macaroni and cheese, green beans, applesauce, cookies). Only children who rated all breakfast entrées as "like a little" or above and who indicated that they would be willing to eat a full bowl of the item were included in the study. Additionally, only children who rated the breakfast side dishes (toast, pop tart, peaches, orange juice, milk), the lunch entrée (chicken nuggets and macaroni and cheese), and at least two of the three lunch side dishes (green beans, applesauce, and cookies) as "just ok" or above were included in the study. Out of the 59 children who were deemed ineligible from the onsite screening, 53 children were excluded due to low preferences for one or more of the experimental foods.

2.5. Experimental meals

Tables 1 and 2 depict the amounts and energy contents of the foods and beverages served at breakfast and lunch. All meals were prepared in a research kitchen according to a standardized protocol. All foods/beverages were weighed prior to being served to children, and reweighed after children finished eating, to determine the amount consumed by each child to the nearest 0.1 g. Information from nutrition facts labels was used to convert the amounts consumed to energy intake.

2.5.1. Breakfast

On the morning of each study visit, children were served one of three compulsory, isocaloric breakfasts: eggs, oatmeal, or cereal. The egg breakfast consisted of scrambled eggs (prepared with 1/8 tsp. table salt), toasted whole wheat bread, diced peaches, and milk (1% fat). The oatmeal breakfast consisted of instant oatmeal (prepared with 6 g salted butter and 184 g whole milk), toasted whole wheat bread, diced peaches and milk (1% fat). The cereal breakfast consisted of ready-to-eat breakfast cereal with milk (1% fat), half a toasted pop tart (strawberry), and orange juice. The percent energy from protein provided by the egg, oatmeal, and cereal breakfasts was 21%, 14%, and 8%, respectively. Calories provided during breakfast (350 kcal) comprised approximately 19% of children's daily estimated energy requirement. The

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