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Impact of Portion Size and Energy Density on Snack Intake in Preschool-Aged Children

SHANNON M. LOONEY, MPH, RD; HOLLIE A. RAYNOR, PhD, RD, LDN

ABSTRACT

The influence of dietary environmental factors on child weight status may be important in the battle against childhood obesity. Portion size and energy density are factors shown to impact entrée energy intake in children. However, the influence of these factors on child snack energy intake has not been studied. Thus, the aim of this study was to investigate the impact of portion size on intake of a lower energy-dense and higher energy-dense snack in preschool-aged children. A 2×2 crossover design (within-subject factors of portion size and energy density) was conducted on Wednesdays in a preschool setting on the University of Tennessee campus from October 2008 to November 2008. Seventeen children had complete data (age 3.8±0.6 years; 10 of 17 were female; 14 of 17 were white). Foods were applesauce (lower energy dense=0.43 kcal/g) and chocolate pudding (higher energy dense=1.19 kcal/g), and portion sizes were 150 g (small) and 300 g (large). Measures included anthropometrics, hunger, liking of foods, and caretakers' child-feeding practices using validated instruments. Mixed factorial analyses of covariance, with order controlled, analyzed gram and energy snack intake across conditions. There was no significant main effect of energy density on snack intake, but the main effect of portion size on snack intake (small portion size 84.2±30.8 kcal, large portion size 99.0±52.5 kcal; $P<0.05$) was significant. Results indicate increased energy intake when snacks are offered in larger portion size, regardless of energy density. Snack portion size may be an environmental strategy that can reduce excessive energy intake in children.

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To prevent childhood obesity, a greater understanding of dietary environmental factors that influence energy intake are needed. Two dietary environmental factors shown to influence entrée energy intake in preschool-aged children are portion size and energy density, with greater portion size and energy density of served entrées producing greater energy intake (1-7). For example, Fisher (1) found larger entrée portion size increased gram and energy intake in children as young as 2 years of age in a laboratory setting. When entrées of higher energy density, calculated as kilocalories per gram, were served to children 2 to 6 years, greater energy intake occurred, but gram consumption was not substantially affected (4,5,7).

As both portion size and energy density independently influence energy intake, when combined these dietary environmental factors may have additive effects. However, Fischer and colleagues (6) examined the effects of portion size and energy density on food and energy intake in children aged 5 to 6 years in a laboratory setting and found that energy intake was 15% greater when the larger portioned entrée was served and total meal energy was 18% higher when served the high-energy-density entrée than when served the lower-energy-density entrée, but no interaction of the two variables occurred. Leahy and colleagues (7) found energy intake to be substantially affected by energy density, but not portion size of the entrée, and no interaction between energy density and portion size in children aged 2 to 5 years in a university preschool setting.

Young children consume a substantial amount of energy from snacks (8-10). Although previous studies examining portion size and energy density on energy intake have tested this within a meal and manipulated these variables in entrée items (11), little research has examined the influence of these variables on energy intake in snacks. Therefore, this study investigated the impact of portion size and energy density on intake, both grams and kilocalories, of snacks in preschool-aged children. It was hypothesized a greater intake (grams and energy) would occur with a larger portion size snack, and a greater intake of energy, but not grams, would occur with a higher energy density snack.

METHODS

Study Design

This study was a 2×2 cross-over design with the within-subject factors of portion size (small vs large) and energy density (applesauce [lower energy dense] vs pudding [higher energy dense]). Four sessions lasting no longer than 30 minutes took place in a preschool setting on Wednesday afternoons, every other week from October 2008 to November 2008. Two classrooms participated and foods were presented in differing orders between the classrooms to control for order effects. Order one received the higher-energy-dense snack (small then large portion

S. M. Looney is a doctoral student and H. A. Raynor is an associate professor, Department of Nutrition, University of Tennessee, Knoxville.

Address correspondence to: Shannon M. Looney, MPH, RD, Department of Nutrition, University of Tennessee, 1215 W. Cumberland Ave, JHB 229, Knoxville, TN 37996-1920. E-mail: slooney1@utk.edu

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size for the first two sessions) subsequently followed by the lower-energy-dense snack (small then large portion size for the last two sessions), and order two received the lower-energy-dense food and large portion size first. Dependent variables were grams and energy of snack consumed.

Participants

Families with children (aged 2 to 5 years) attending full-day preschool (n=32) at the Early Learning Center on the University of Tennessee Knoxville campus were informed about the study by letters. Interested families received two parental consent forms and questionnaires to take home and complete. Children were ineligible to participate if they did not receive parental consent, their caretaker reported that they were unable to use a spoon, were lactose-intolerant, or were allergic to and/or disliked foods used in the study. Of the children in the two classrooms, five caretakers did not provide consent and two disliked the snack foods and were ineligible for the study. In addition, four children were absent at least 1 data-collection day. Although 21 children completed all sessions of the study, 4 children were excluded from the analyses because they consumed <5 kcal in at least one session. This study was approved by the Institutional Review Board at the University of Tennessee Knoxville.

Foods

Foods that were part of the Early Learning Center menu (each offered monthly), amorphous, and consumed with spoons—unsweetened applesauce (lower-energy-dense food, 0.43 kcal/g) and chocolate pudding, made with 2% milk (higher-energy-dense food, 1.19 kcal/g)—were used in this study. Small portion size was 150 g (lower-energy-dense=64.5 kcal; higher-energy-dense=178.5 kcal) and large portion size was 300 g (lower-energy-dense=129 kcal; higher-energy-dense=357 kcal). The small portion size used (150 g≈5.3 oz) is similar to the preportioned (4 oz) applesauce and pudding found in grocery stores. The amount provided to children was similar to that used in a study by Leahy and colleagues (7). Water was available to children ad libitum, which is standard practice during snack time at the Early Learning Center. Intake of water was not measured.

Procedures

For each session, children were provided a standard lunch, (family style) from the Early Learning Center. The same lunch menu was used for all intervention days. Three hours after lunch, children completed measures of hunger and liking of the foods with the help of research assistants before receiving their snack. Preportioned snacks, as typically served at the Early Learning Center, were passed out and children were asked not to share their snack and to eat as much or as little of their snack as desired. Children sat at the table with a classroom attendant, which was standard procedures at the Early Learning Center, and a research assistant while they consumed their snack until reported being done. Children had a maximum of 30 minutes to consume the snack, but could leave the table during the 30 minutes when done with their snack. Once all data were collected, all families with children that completed all measures were entered in a drawing for a prize ($50.00 gift certificate).

Measures

Anthropometrics. In the first session, anthropometrics of children were measured by the research team. Children removed shoes and any excess clothing before being measured. Weight was measured to one-tenth of a pound using a calibrated portable digital scale (Healthometer Professional, Sunbeam Product Inc, Boca Raton, FL). The height of each child was measured twice to the nearest eighth of an inch using a portable stadiometer (SECA, ITIN Scale Company, Brooklyn, NY). Body mass index (BMI) was calculated as kg/m^2. The research team calculated children's BMI z score by standardizing the BMI value in relation to the population mean and standard deviation for children's age and sex (12,13). Children's BMI was also compared to the Centers for Disease Control and Prevention's BMI percentile charts to determine overweight/obese status (12,13).

Consumption. Snacks were measured by the research team before and after consumption to the nearest tenth of a gram using a calibrated food scale (Denver Instruments SI-8001, Fisher Scientific, Arvada, CO). Amount of snack consumed was determined by subtracting post-snack weight from pre-snack weight. Snack energy intake was determined using Nutrition Data System for Research software (developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN, version 2008, 2008). If spillage occurred during consumption, the research team collected the spilled food and returned it to the bowl.

Liking of Foods. Liking of each food was assessed with the aid of a trained research assistant before each snack was served at each session, using a three-point Likert-type scale (1=like; 2=neutral; 3=dislike) anchored with faces showing an expression of like (smile face), neutrality, and dislike (frown face) similar to those used previously (6,14). Lower values represented greater liking.

Hunger. The hunger of children was assessed with the aid of trained research assistants before each snack was served at each session with a tool developed by Birch (14) and used in previous studies (1,2,6). A series of three cartoon drawings of an individual was presented, similar to a 3-point Likert-type scale (1=very hungry; 2=neutral; 3=not hungry). The first cartoon drawing had a stomach with no shading to represent "very hungry" and the shading increased to the last stomach being fully shaded representing "not hungry." Lower values represented greater hunger.

Caretaker Questionnaires

Caretakers completed three questionnaires at home: a demographic questionnaire, the Child Feeding Questionnaire (CFQ) (15), and the Three Factor Eating Questionnaire (TFEQ) (16,17). The CFQ assesses seven factors: perceived responsibility, perceived parent weight, perceived child weight, concern about child weight, restriction, pressure to eat, and monitoring (15). Higher numbers represent greater values on each factor. The TFEQ

Table 1. Selected demographic and anthropometric characteristics of preschool-aged children, along with their primary caretaker, who completed a feeding study in Knoxville, TN

Characteristics	Child (n=17)	Caretaker (n=17)
Age (y), mean±SD[a]	3.8±0.6	36.5±6.4
z-BMI,[b] mean±SD	0.01±1.06	—
BMI[c] percentile, mean±SD	50.2±32.4	—
Overweight (≥85th percentile), n (%)	5/17 (29)	—
Sex (M[d]/F[e])	7/10	4/13
Race (nonwhite/white)	3/14	0/17
Ethnicity (Hispanic/non-Hispanic)	1/16	0/17
Caretaker marital status (married)	—	16/17
Caretaker relationship to child	—	
Mother		13
Father		3
Other		1
Caretaker education status	—	
Grade school (≤6 years)		1
Some college (≤4 years)		1
College/university degree		4
Graduate or professional degree		11

[a]SD=standard deviation.
[b]*z* BMI=standardized body mass index.
[c]BMI=body mass index.
[d]M=males
[e]F=females.

measured the parent's eating style with three scales: Dietary Restraint, Disinhibition, and Perceived Hunger (16,17). Each factor is scored on a scale as higher numbers represent greater dietary restraint (0 to 21), disinhibition (0 to 16), and perceived hunger (0 to 14). The CFQ and TFEQ are validated instruments used in child feeding studies to measure parent characteristics that might influence child consumption (16-18).

Data Analysis

Data analysis was conducted using SPSS (version 17.0, 2007, SPSS Inc, Chicago, IL), with an α level of $<.05$ for significance. For baseline demographic information, independent t tests and χ^2 analyzed for differences between orders. To assess for potential differences in hunger and liking between the sessions, repeated measures analyses of covariance with the within-subject factors of portion size and energy density, and order as a covariate, were conducted. Repeated measures analyses of covariance with the within-subject factors of portion size and energy density and order as a covariate were also used to assess the dependent variables grams/energy of food consumed. To examine the relationship between child and caretaker demographics, and caretaker feeding and eating factors (CFQ and TFEQ), and intake, correlations were conducted to determine which of these factors were related to gram and energy intake. Those variables that were closely related to intake were entered into hierarchical linear regressions, with order forced into the first level, child demographics stepwise entered into the second level, and caretaker demographics and caretaker feeding and eating factors stepwise entered into the third level.

RESULTS AND DISCUSSION

Child and Caretaker Demographics

The 17 children included in the analysis were aged 3.8±0.6 years, with a mean BMI *z* score of 0.01±1.06 and BMI percentile of 50.2±32.4. Five children (29.4%) were overweight (BMI percentile ≥85th percentile). Of the 17 children, 10 were female, 14 were white, and 16 were non-Hispanic. Child and caretaker demographics are displayed in Table 1. There were no differences in child and caretaker demographics between the orders (Table 1 and Table 2).

Hunger and Liking of Foods

There was no substantial interaction or main effect of portion size or energy density on hunger or liking ratings of the foods during the four sessions. The mean hunger rating across all sessions was 1.3±0.4, indicating the children were hungry and the mean liking rating for both foods across all sessions was 1.3±0.5, demonstrating that children liked the foods.

Intake

A significant ($F=5.21$; $P<0.05$) main effect of portion size occurred, with greater energy consumed in the large as compared to small portion (99.0±52.5 kcal vs 84.2±30.8 kcal); however, there was no main effect of energy density or interaction of energy density and portion size on energy intake. There were no significant main effects or interactions for gram intake ($P>0.05$).

As only portion size was related to intake, hierarchical regressions were conducted to examine factors that were

Table 2. Mean score responses from the primary caretakers' practices, beliefs, and attitudes about child feeding using the Child Feeding Questionnaire and caretaker eating style using the Three Factor Eating Questionnaire

	← mean± standard deviation →
Child Feeding Questionnaire factors	
Perceived responsibility[a]	4.2±0.6
Perceived parent weight[b]	2.8±0.3
Perceived child weight[b]	2.7±0.5
Concern about child weight[c]	1.5±0.5
Restriction[d]	3.6±0.6
Pressure to eat[d]	2.3±1.1
Monitoring[a]	3.6±1.2
Three Factor Eating Questionnaire factors	
Dietary restraint[e]	9.2±4.0
Disinhibition[f]	3.3±2.1
Perceived hunger[g]	5.5±3.0

[a]Perceived responsibility and monitoring scored on a 5-point scale: 1=never; 2=seldom; 3=half of the time; 4=most of the time; 5=always.
[b]Perceived parent weight and perceived child weight scored on a 5-point scale: 1=markedly underweight; 2=underweight; 3=normal; 4=overweight; 5=markedly overweight.
[c]Concern about child weight scored on a 5-point scale: 1=unconcerned; 2=a little concerned; 3=concerned; 4=fairly concerned; 5=very concerned.
[d]Restriction and pressure to eat scored on a 5-point scale: 1=disagree; 2=slightly disagree; 3=neutral; 4=slightly agree; 5=agree.
[e]Dietary restraint (factor I) is scored over a range of 0 to 21 with lower values representing lower dietary restraint.
[f]Disinhibition (factor II) is scored over a range of 0 to 16 with lower values representing lower disinhibition.
[g]Perceived hunger (factor III) is scored over a range of 0 to 14 with lower values representing lower perceived hunger.

related to intake, both grams and kcals, for the small and large portion size, with the two foods combined. When the relationship between child demographics, caretaker demographics, and CFQ and TFEQ factors were examined in relation to child intake of the small portion size and large portion size, significant correlations were found for intake of grams of small portion size and pressure to eat ($r=-0.45$, $P=0.04$), and grams of large portion size and pressure to eat ($r=-0.47$, $P=0.03$). Correlations between race or ethnicity and intake were not conducted due to the lack of variability of these demographic characteristics. When pressure to eat was entered stepwise into a hierarchical regression with order controlled, it was not related to gram intake for either portion size.

It was hypothesized that preschool-aged children would consume greater grams and energy from the large portion size and greater energy but not grams from the higher-energy-dense snack. This study found that greater energy intake occurred in the large portion-sized snack. These findings are similar to those of previous investigations (1-3). Interestingly, this study did not find an effect of energy density on energy intake. This is contrary to other studies that have found increasing energy density by 30% in an entrée resulted in a 25% increase in energy consumed (4) and an energy-density meal and beverage increase of 27% led to a 25% increase in energy intake (5). The difference in findings with energy density in this investigation may have been a consequence of the relatively low energy density of both foods (lower energy dense 0.43 vs higher energy dense 1.19), as previous studies that have found an effect of energy density on energy intake in children have used foods in which even the lower energy-dense food had an energy density ≥1.2 kcal/g (4-6). Thus, while the foods used in this investigation had a large difference in energy density (ie, higher-energy-dense food was almost three times higher in energy density than the lower-energy-dense food), there might be a threshold level of energy density that is required for changes in energy density to influence energy intake.

Strengths of the study include the objective measures of intake and foods were both amorphous and eaten with a spoon. Limitations include the small sample size in addition to a fairly homogenous sample of children who were white and from families of higher socioeconomic status. In addition, this investigation was limited to 1 day of the week during 1 month of one season.

CONCLUSIONS

Study outcomes indicate that snacks served in a large portion size increase energy intake in preschool-aged children. Although the difference in energy intake consumed between the two portion sizes was small, the additive effect of this difference may be important because children may consume multiple snacks within a day and throughout the week. Therefore, this study suggests that snack portion size may be an environmental strategy that dietetics practitioners could recommend to assist in reducing excessive caloric intake from snacks in young children.

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