An After-School Snack of Raisins Lowers Cumulative Food Intake in Young Children

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Abstract: Snacks are an important part of children's dietary intake, but the role of dried fruit on energy intake in children is unknown. Therefore, the effect of *ad libitum* consumption of an after-school snack of raisins, grapes, potato chips, and chocolate chip cookies on appetite and energy intake in twenty-six 8- to 11-y-old normal-weight (15th to 85th percentile) children was examined. On 4 separate weekdays, 1 wk apart, children (11 M, 15 F) were given a standardized breakfast, morning snack (apple), and a standardized lunch. After school, children randomly received 1 of 4 *ad libitum* snacks and were instructed to eat until "comfortably full." Appetite was measured before and 15, 30, and 45 min after snack consumption. Children consumed the least calories from raisins and grapes and the most from cookies ($P < 0.001$). However, weight of raisins consumed was similar to potato chips (about 75 g) and lower compared to grapes and cookies ($P < 0.009$). Raisins and grapes led to lower cumulative food intake (breakfast + morning snack + lunch + after-school snack) ($P < 0.001$), while the cookies increased cumulative food intake ($P < 0.001$) compared to the other snacks. Grapes lowered appetite compared to all other snacks ($P < 0.001$) when expressed as a change in appetite per kilocalorie of the snack. *Ad libitum* consumption of raisins has potential as an after-school snack to achieve low snack intake prior to dinner, similar to grapes, compared to potato chips, and cookies in children 8 to 11 y old.

Keywords: children, food intake, raisins, snacking

Practical Application: Children do not consume an adequate amount of fruit and commonly consume snacks that tend to be high in energy and fat, suggesting a need to identify healthy snacks that contribute to nutrient intake, suppress appetite, and reduce caloric intake at later meals. Raisins, the most commonly consumed dried fruit snack, and grapes, may be used to increase fruit intake in children. Results indicate that an after-school snack of raisins, similar to grapes, contributes to lower daily energy intake, making them a nutrient-rich snack for children.

Introduction

Snacks are an important part of children's dietary intake. Although increased consumption of snacks by children and adolescents is suggested to contribute to overweight (Francis and others 2003; Kant 2003; Nicklas and others 2003), a comprehensive review did not find snacking to be causally associated with body weight (Johnson and Anderson 2010).

In addition to providing energy, snacks are necessary for children to meet their nutritional requirements (Sebastian and others 2008; Johnson and Anderson 2010). The time between lunch at school and dinner at home is a critical period in a child's daily nutrient intake (American Academy of Pediatrics 2010). The majority of snacks served in after-school environments are low in nutrient density and high in energy, including those with added sugar (such as cookies) or salty snacks (such as potato chips) (Mozaffarian and others 2010). However, after-school snacking may be an opportunity to offer nutrient-rich snacks, such as fruit, which is normally consumed below recommendations by children (Guenther and others 2006; Garriguet 2007).

Nutritional guidelines for after-school programs consistently endorse serving whole fruit and limiting snacks high in sugar, fat, and calories, but currently no guidelines exist for the inclusion of dried fruit as an after-school snack (Beets and others 2011). Whole fruits may be promoted over more energy-dense snacks, despite their low energy density (Rolls 2010), because food volume increases feelings of fullness (Flood-Obbagy and Rolls 2009). Although energy-dense, raisins, the most commonly consumed dried fruit snack, (Keast and others 2011) are a source of dietary fiber (30% soluble), antioxidants, potassium, and iron (US Dept. of Agriculture Nutrient Database for Standard Reference 2007), and dried fruit consumption was associated with improved diet quality and lower body weight in adults participating in the Natl. Health and Nutrition Examination (NHANES) survey of 1999 to 2004 (Keast and others 2011). A study in adults showed that 1 cup of raisins per day, alone or combined with walking, had no effect on body weight, fasting glucose, or insulin (Puglisi and others 2008),

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Table 1–Baseline characteristics of test subjects.[a]

Subject characteristics	All children
Age (y)	10.1 ± 0.2
Body weight (kg)	33.1 ± 1.0
Height (m)	1.39 ± 0.01
BMI (kg/m^2)	17.0 ± 0.3
BMI percentile	51.9 ± 5.3
DEBQ[b]	1.6 ± 0.1

[a]Data are means ± SEM; $n = 26$ (11 boys and 15 girls).
[b]Dutch eating behavior questionnaire.

but increased leptin and ghrelin levels after 6 wk (Puglisi and others 2009), suggesting improved balance of appetite-regulating hormones.

In children 8 to 11 y old, premeal snacks of raisins given *ad libitum* lowered cumulative energy intake at an *ad libitum* meal 30 min later compared to grapes and a mix of raisins and almonds, and was similar to water. In contrast, grapes and the mixed snack resulted in higher cumulative energy intakes compared to water (Patel and others 2012). These findings support a role for raisins as a satiating premeal snack, but it is unclear how raisins given as an after-school snack may affect energy consumed over a child's day. No studies have reported the effect of after-school snacking on raisins compared to other commonly consumed snacks on energy intake in children.

Therefore, the objective of this study was to examine appetite and energy intake following *ad libitum* consumption of an after-school snack of raisins, grapes, potato chips, and chocolate chip cookies in children 8 to 11 y old.

Materials and Methods

Subjects

Normal-weight boys and girls (11 M, 15 F; 8 to 11 y) were recruited by word of mouth and through advertisements in the local newspaper. Baseline characteristics are reported in Table 1. The Univ. Research Ethics Board of Mount Saint Vincent Univ. approved this study.

To participate, children had to be normal weight (between 15th and 85th percentile for age and sex) based on the Centers for Disease Control and Prevention growth charts (Ogden and others 2002), born at full-term and at a normal birth weight. Individuals dieting, taking medication, and with any significant learning, behavioral, or emotional difficulties were excluded to ensure rigorous compliance to all aspects of the study design. Telephone interviews were conducted initially with a parent of the potential participant. When a child met the study requirements, a screening was made at the Applied Human Nutrition Dept., where informed consent was obtained from a parent and assent was obtained from the child. Participants' heights (m) were measured using a stadiometer and weight (kg) was recorded from a digital scale while subjects wore light clothing. The children were told that the purpose of the study was to examine children's snack preferences. They were familiarized with visual analogue scale (VAS) questionnaires used in the study and the parent and child were given a tour of the facility in order to minimize apprehension during the 1st test visit.

Study design

A within-subjects repeated measures design was used to measure children's energy intake and subjective appetite following consumption of 4 *ad libitum* snacks. On 4 separate weekday afternoons (between 3:30 pm and 4:00 pm), in random order 1 wk apart, children were given grapes, raisins, potato chips, or chocolate chip cookies to consume (within 15 min). A standardized breakfast of Baxters® fat-free skim milk (250 mL, 90 kcal), Cheerios® (28 g, 100 kcal) and Tropicana Orange Juice® (236 mL, 110 kcal), a morning snack (1 medium apple, 72 kcal), and lunch consisting of a turkey sandwich on white bread with lettuce, tomato, mayonnaise, and mustard (369 kcal) and Baxters® 2% milk (250 mL, 130 kcal) were consumed on test days prior to the child's arrival to the laboratory. The standardized intake was designed to provide 54% and 58% of Health Canada's estimated energy requirements for each boy and girl, respectively, adjusted for age, body weight, height, and physical activity level (Dietary Reference Intake Tables 2011). The rationale for the controlled intake during the day was to account for variability in energy intakes of the children.

Protocol

Participants arrived at Evaristus Hall, Dept. of Applied Human Nutrition, between 3:30 pm and 4:00 pm, after consuming the standardized breakfast at home and standardized snack and lunch at school, whereby compliance was assessed with a questionnaire. Upon arrival, children completed VAS measuring their subjective appetite and physical comfort (Bellissimo and others 2007a, 2007b; 2008a, 2008b; Bozinovski and others 2009; Patel and others 2011; Tamam and others 2012). VAS for pleasantness and sweetness of the snacks were administered immediately after snack consumption. Motivation-to-eat VAS, which measure dimensions of subjective appetite (Stubbs and others 2000), was composed of 4 questions: (1) How strong is your desire-to-eat? ("very weak" to "very strong"); (2) How hungry do you feel? ("not hungry at all" to "as hungry as I've ever felt"); (3) How full do you feel? ("not full at all" to "very full"); and (4) How much food do you think you can eat? (prospective food consumption, PFC) ("nothing at all" to "a large amount"). Children were instructed to read each question and place an "x" along the 100-mm line depending on their current feelings. Physical comfort was assessed by "How well do you feel?" ("not well at all" to "very well"). Pleasantness of the snack was assessed by "How pleasant have you found the snack ("not pleasant at all to very pleasant"), while sweetness of the snack was assessed by "How sweet have you found the snack? ("not sweet at all to very sweet"), and both VAS were administered immediately after snack consumption.

Participants were escorted into the taste panel room and individually seated in their own cubicle, free of external cues, and served 1 of the 4 *ad libitum* test snacks, which were assigned in random order. They were also provided with a 500-mL bottle of natural spring water (Nestle®, Pure Life®) and instructed to eat and drink until they were "comfortably full" while seated for a 15-min duration.

The 4 snacks were raisins (California seedless; donated by California Raisin Marketing Board), grapes (Dole; purchased at Sobey's), potato chips (Lays Classic, Lays Canada), and chocolate chip cookies (Chips Ahoy!, Mr. Christie). Snacks were served in 500-mL clear plastic containers (about 210 kcal) provided as 65 g raisins, 301 g grapes, 45 g cookies, and 38 g potato chips. Participants were initially provided with 1 container and additional containers of snacks were available upon request during the 15-min measurement interval. The amount of snack and water left after 15 min was subtracted from the initial weight to measure snack and water intake. Each snack was weighed separately and the energy consumed (in kcal) was calculated. The macronutrient composition of the snacks was calculated using food composition

tables from the US Dept. of Agriculture (US Dept. of Agriculture Nutrient Database for Standard Reference 2007). At 15 min, children completed VAS for palatability, sweetness, motivation-to-eat, and physical comfort, which were repeated at 30 and 45 min.

Eating behavior assessment

The Dutch Eating Behaviour Questionnaire was administered to assess restrained eating (van Strien and Oosterveld 2008). Children received assistance in case of difficulty interpreting the questionnaire's language.

Statistical analyses

Energy intake, water intake, and sweetness and pleasantness of the snacks were analyzed by the MIXED model procedure in SAS 9.2 (SAS Inst. Inc., Carey, N.C., U.S.A.), using a one-way repeated measures analysis of variance (ANOVA). Two-way repeated measures ANOVA using the MIXED model procedure was used to analyze the effects of time, treatment, and their interaction on appetite and physical comfort. Results were pooled for boys and girls since there were no gender differences. *Post hoc* analysis by the Tukey–Kramer test was performed when treatment effects were found to be statistically significant. An average appetite score was calculated at each time of measurement for each treatment by the formula:

$$\text{appetite score} = [\text{desire-to-eat} + \text{hunger} + (100 - \text{fullness}) + PFC]/4,$$

which reflects the 4 questions on the motivation-to-eat VAS as used previously (Woodend and Anderson 2001; Anderson and others 2002; Anderson and Woodend 2003) and validated by Lluch and others (2010). Cumulative food intake was calculated from the sum of calories consumed from the breakfast, morning snack, lunch, and *ad libitum* snack.

On the basis of an earlier study investigating raisins as a snack before a meal (Patel and others 2012), a sample size of 26 is powered to see an approximate 135 kcal difference in cumulative intake after the raisins compared to the grapes with a within-subject SD of approximately 180 kcal.

Data are presented as means ± standard error of mean (SEM). Significance was considered at $P < 0.05$. Correlations on dependent measures were conducted by use of Pearson's correlation coefficients.

Results and Discussion

Intake, energy density, and composition of snacks

Treatment affected snack intake ($P < 0.001$), cumulative food intake ($P < 0.001$), and water intake ($P = 0.003$, Table 2). Snack intake (kcal) was lowest after raisins and grapes ($P < 0.001$) and highest after cookies ($P < 0.040$), compared with all other snacks. However, children consumed less weight from raisins and potato chips, compared to grapes and cookies ($P < 0.009$), and less weight from cookies compared to grapes ($P < 0.001$). Similarly, cumulative food intake (kcal) was lowest after raisins and grapes ($P < 0.001$) and highest after cookies ($P < 0.011$), compared to all other snacks. There are no other published reports of the effect of dried fruit as snacks on energy intake in children. However, the reduction on cumulative intake after the raisin snack is consistent with a study showing that a preload including dried prunes reduced total energy intake at a later meal compared to an isocaloric and equal weighed bread product preload in normal-weight adults (Farajian and others 2010).

Table 2–Effect of *ad libitum* treatments on snack intake, water intake, and cumulative food intake.[a]

	Grapes[f]	Raisins	Potato chips	Cookies	*P*
Snack intake[b] (kcal)	177 ± 17[a]	228 ± 21[a]	413 ± 20[b]	505 ± 32[c]	<0.001
Snack intake[c] (g)	254 ± 24[a]	75 ± 7[b]	74 ± 4[b]	108 ± 7[c]	<0.001
Water intake[d] (g)	374 ± 37[b]	256 ± 25[a]	276 ± 27[a]	273 ± 29[a]	0.003
Cumulative food intake[e] (kcal)	1049 ± 17[a]	1099 ± 21[a]	1284 ± 20[b]	1376 ± 32[c]	<0.001

[a]Data are means ± SEM; $n = 26$. One-factor ANOVA for treatment effect followed by Tukey's *post hoc* test.
[b]Energy consumed at the *ad libitum* snack.
[c]Weight consumed at the *ad libitum* snack.
[d]Weight of water consumed (g) during *ad libitum* snack intake including the amount of water in grapes.
[e]Cumulative food intake from breakfast, morning snack, and lunch (871 kcal), and *ad libitum* after-school snack.
[f]Water consumed at the snack includes the amount of water present in grapes.
[a,b,c] Mean values within a row with unlike superscript letters are significantly different ($P < 0.05$).

Table 3–Composition of snacks.[a]

	Grapes	Raisins	Potato chips	Cookies
Total CHO (g)	16.8	73.5	51.7	62.4
Protein (g)	0.8	3.6	6.7	4.9
Total fat (g)	0.2	0.5	37.1	22.7
Total sugars (g)	15.9	69.2	0.4	34.1
Total dietary fiber (g)	0.9	4.3	4.5	2.3
Starch (g)	–	–	46.9	25.7

[a]Composition is calculated per 100 g serving.

Neither energy density nor volume predicted the effect of the snack on cumulative energy intake. The energy densities of raisins (3.04 kcal/g), chips (5.58 kcal/g), and cookies (4.68 kcal/g) were higher than for grapes (0.69 kcal/g), but grapes and raisins had similar effects on cumulative food intake. These findings are consistent with reports showing that there is a disconnect between preload volume and food intake (Gray and others 2002). In males, food intake following a high-volume and high-energy-dense soup preload was lower compared to after soups of low-volume and low-energy density or low-volume and high-energy density or high-volume and low-energy density, which did not differ from one another (Gray and others 2002). Although energy density of grapes was low, the role of water content is unclear. Water intake was highest after grapes compared with all other snacks ($P < 0.033$) due to the high water content of the grapes. Previous studies show that when water was the dominant component of a food's energy density, energy intake was not related to the energy density of that food (Westerterp-Plantenga 2001). However, water content in the grapes may have helped to lower snack and cumulative energy intake, similar to a study showing that a low-energy-dense soup preload lowered lunchtime energy intake by women compared to a similar serving of calories from a casserole and casserole with water (Rolls and others 1999). In addition, weight of the snack consumed was not explained by energy content, since children consumed the same weight from raisins and potato chips (Table 2).

Macronutrient composition of the snacks may have been a factor affecting cumulative food intake (Table 3). Sugars regulate physiological satiety signals in normal-weight adult men and children and suppress food intake when given 30 min prior to a meal (Birch and Deysher 1986; Rodin 1990; Anderson and others 2002;

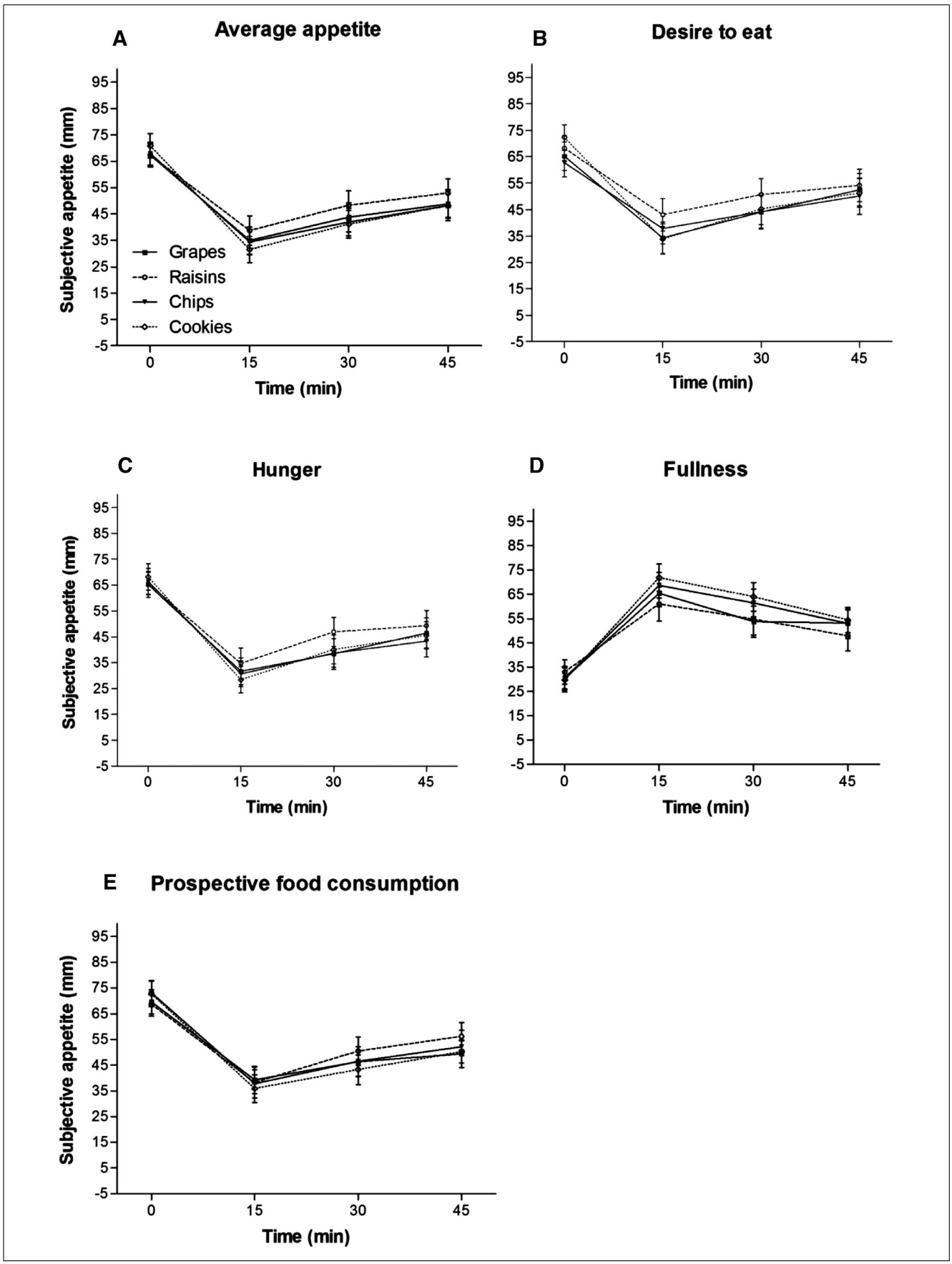

Figure 1–Absolute scores for average appetite (A), desire-to-eat (B), hunger (C), fullness (D), and prospective food consumption (E).

Table 4–Effect of *ad libitum* treatments on sweetness and pleasantness of the snacks.[1]

	Grapes	Raisins	Potato chips	Cookies	*P*
Sweetness (mm)	62 ± 6[ab]	56 ± 6[ab]	48 ± 7[a]	72 ± 5[bc]	0.024
Pleasantness (mm)	70 ± 6[a]	49 ± 7[b]	92 ± 2[c]	87 ± 4[c]	<0.001

[a]Data are means ± SEM; $n = 26$. One-factor ANOVA for treatment effect followed by Tukey's *post hoc* test.
[a,b,c]Mean values within a row with unlike superscript letters are significantly different ($P < 0.05$).

Bellissimo and others 2008a). The carbohydrate (sugars) content of raisins was associated with an increase in leptin levels after 6 wk of raisin consumption (Puglisi and others 2009). The children consumed similar amounts of carbohydrate, primarily as the sugars glucose and fructose from the grapes (about 43 g carbohydrate/254 g of grapes) and raisins (about 55 g carbohydrate/75 g of raisins), but the greatest amount from the cookies (about 69 g carbohydrates/108 g of cookies) (Table 3), which led to the greatest cumulative food intake compared to the other snacks.

Furthermore, protein, fat and starch, but not dietary fiber, differed among the snacks (Table 3). The amount of potato chips (74 g) and cookies (108 g) consumed had the greatest amounts of protein, fat and starch, while all the snacks had similar amounts of dietary fiber, which is unlikely to have been a factor on food intake. However, the greater amount of calories consumed from the cookies and resultant higher cumulative food intake may be due to its saturated fat content. Snacks with higher fat content have been shown to increase cumulative energy intake in children (Birch and others 1993), and foods high in fat are less satiating than high carbohydrate foods (Holt and others 1996). Children (3 to 16 y) also exhibit a strong preference for fatty, sugary, and savory foods (Cooke and Wardle 2005), and this may have influenced consumption of the snack.

Pleasantness and sweetness of snacks

Palatability is a determinant of children's energy intake (Fisher and Birch 1995; Rasmussen and others 2006; McClain and others 2009). Sweetness and pleasantness differed among snack treatments ($P = 0.024$, Table 4). Sweetness following consumption of chocolate chip cookies was significantly higher than potato chips ($P = 0.016$). Raisins ($P < 0.001$) and grapes ($P < 0.045$) were rated less pleasant compared to potato chips and cookies, while grapes were rated more pleasant than raisins ($P = 0.004$). Palatability of grapes ($r = 0.087$, $P = 0.673$), potato chips ($r = 0.046$, $P = 0.823$), and cookies ($r = 0.014$, $P = 0.945$) was not associated with snack intake. However, palatability of raisins (0.527, $P = 0.006$) was positively associated with snack intake. Overall palatability of the snacks was not associated with average snack intake ($r = -0.084$, $P = 0.683$). Sweetness of grapes, ($r = -0.067$, $P = 0.746$), raisins (0.323, $P = 0.108$), potato chips ($r = 0.106$, $P = 0.604$), and cookies ($r = 0.129$, $P = 0.530$) was not associated with snack intake. Therefore, the inclusion of highly palatable snack foods that children frequently consume (including chips and cookies) (Cooke and Wardle 2005) may have contributed to the relatively lower ratings for raisins.

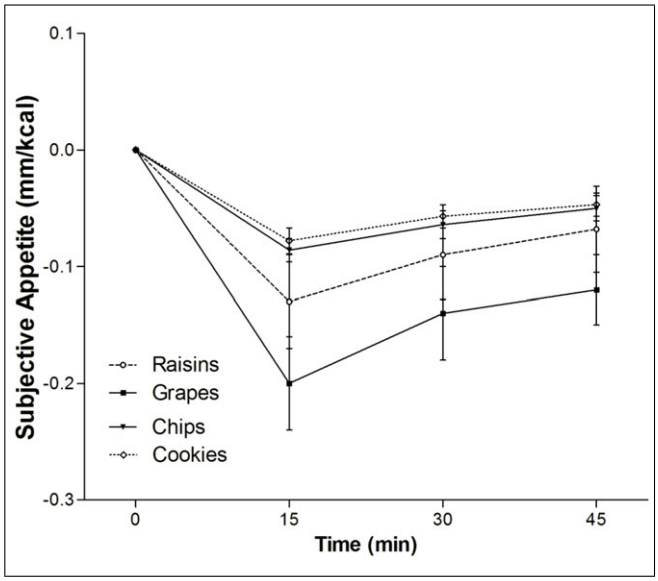

Figure 2–Change from baseline subjective appetite scores per kilocalorie of snack intake.

Subjective appetite scores

In contrast to previous studies showing increases in appetite and decreases in fullness in children after liquid preloads (Bellissimo and others 2008a, 2008b; Patel and others 2011), appetite scores were lower and fullness higher after the solid snacks, irrespective of composition ($P < 0.001$; Figure 1A). This suggests that children are better able to assess subjective feelings of fullness and hunger after solid foods compared to liquids. For individual appetite scores, snack was not a factor, but desire-to-eat, hunger, and PFC decreased and fullness increased over time (Figure 1B to E). Since children felt similarly full after each treatment despite differences in caloric intake of the snacks, appetite data were reported as the change from baseline per kcal of treatment consumed. When expressed as a change in appetite per kilocalorie of the snack, an effect of treatment was observed for average appetite ($P < 0.001$; Figure 2), desire-to-eat ($P = 0.001$; data not shown), hunger ($P < 0.001$, data not shown), fullness ($P = 0.001$, data not shown), and PFC ($P = 0.002$, data not shown). All snacks reduced average appetite, but appetite following consumption of the grapes was lowest during the study measurement period compared with all other snacks, suggesting that grapes increased satiety after the *ad libitum* snack, possibly due to its water content. This may have implications on later food intake.

Baseline (Time 0) average appetite ($r = 0.598$, $P = 0.001$), desire-to-eat ($r = 0.399$, $P = 0.043$), hunger ($r = 0.447$, $P = 0.022$), and PFC scores ($r = 0.671$, $P < 0.001$) were positively, and fullness scores ($r = -0.505$, $P = 0.008$) negatively, associated with snack intake. Physical comfort was affected by treatment only ($P = 0.037$; Figure 1), but *post hoc* analysis revealed only a trend for lower scores after raisins compared to grapes ($P = 0.064$).

The effect of after-school snacks on cumulative food intake is important in promoting foods that will enhance satiety and lower caloric intake in children. However, there are some limitations to the current experiment. First, the daily intake to the snack was controlled. This was done to account for any variability in energy intake between children that may have obscured the consumption of the *ad libitum* snack. Second, it is not possible to generalize our results to overweight/obese children, since all participating children were normal body weight. Third, the snacks used may not represent what children like or to which they have access when a supervisor is absent. Fourth, mealtime energy intake at dinner was not measured due to timing of the afternoon snack interfering with family schedules, since all of the children were brought from school to the department by their parents and were unable to stay

for a 2nd meal. Thus, we cannot assume that cumulative food intake would remain lowest after grapes. As previously shown, a raisin snack prior to lunch reduced energy intake at a meal given 30 min later and did not increase cumulative energy intake compared to water (Patel and others 2012). Future studies should address how an after-school snack/meal full of vegetables, fruits and dairy as well as whole grains help to control weight and appetite in children (Azadbakht and others 2011).

Conclusions

In addition to promoting satiety (Puglisi and others 2009), raisins provide valuable nutrients for children, such as dietary fiber, antioxidants (Camire and Dougherty 2003), vitamin C, potassium, and iron. Thus, raisins may be recommended to increase fruit intake, but future studies are required to determine if an after-school snack of raisins leads to better management of energy intake in children. *Ad libitum* consumption of raisins has the potential as an after-school snack to achieve low snack intake prior to dinner, similar to grapes, compared to potato chips and cookies in children 8 to 11 y old.

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