Association of Nutrient-Dense Snack Combinations With Calories and Vegetable Intake

WHAT’S KNOWN ON THIS SUBJECT: The eating of non–nutrient dense snack foods is considered a major factor contributing to childhood obesity. Parents are often ineffective at encouraging healthier snacking habits.

WHAT THIS STUDY ADDS: Children consumed fewer calories when snacking on nutrient-rich cheese and vegetables compared with when they were served potato chips.

abstract

BACKGROUND: With other factors such as general diet and insufficient exercise, eating non–nutrient dense snack foods such as potato chips contributes to childhood obesity. We examined whether children consumed fewer calories when offered high-nutrient dense snacks consisting of cheese and vegetables than children who were offered non–nutrient dense snacks (ie, potato chips).

METHODS: Two hundred one children (115 girls) entering the third to sixth grades were randomly assigned to 1 of 4 snacking conditions: (1) potato chips only, (2) cheese-only, (3) vegetables only, and (4) cheese and vegetables. Children were allowed to eat snacks freely provided while watching 45-minute TV programs. Satiety was measured before they started eating snacks, in the middle of the study, and 20 minutes after they finished eating the snacks. Parents completed a questionnaire regarding their family environment.

RESULTS: Children consumed 72% fewer calories when eating a combined snack compared with when they were served potato chips, \( P < .001 \). Children who ate the combination snack needed significantly fewer calories to achieve satiety than those who ate potato chips, \( P < .001 \). The effects of the snack conditions on caloric intake were more pronounced among overweight or obese children \( (P = .02) \) and those from low-involvement families \( (P = .049) \).

CONCLUSIONS: The combination snack of vegetables and cheese can be an effective means for children to reduce caloric intake while snacking. The effect was more pronounced among children who were overweight or obese and children from low-involvement families. Pediatrics 2013;131:22–29
The increase in childhood obesity is a major health concern in the United States and around the world. According to NHANES, ~32% of US children (aged 2–19 years old) are overweight or obese (BMI ≥ 85th percentile). Although there are other contributing factors such as reduced physical activity, the increase in snacking and the eating of non–nutrient dense (NND) snack foods could reduce children’s intake of those foods. The results have been mixed. In some studies, parental control has been effective, but in others, they have not. For instance, Fisher and Birch offered snack foods to girls aged 3 to 6 years old (n = 30) without any restrictions on quantity. Those girls whose parents enforced higher restrictions relating to snacking actually ate more snacks than those whose parents imposed fewer similar restrictions. Thus, although parental control can reduce the consumption of restricted foods, parental control can backfire in an unrestricted setting.

This research explores alternatives to parental control in reducing intake of NND snack foods and increasing intake of healthier snack foods. One possible alternative can be adapted from existing research on eating variety. In an experimental study, children provided with an assortment of snack foods consumed more total calories than those provided only with their favorite type of snack food. Therefore, as Epstein et al speculated, increasing the variety of high-nutrient dense (HND) snacks instead of NND snacks could reduce total caloric intake. How much people eat depends not only on energy needs but also on the psychological processes behind the sense of satiety. Because a variety of foods slow habituation, decrease in response (eg, eating) due to a repeated exposure of stimuli (eg, foods), a variety of foods should result in increased intake. This suggests that children provided with a variety of HND rather than NND snack foods may consume more nutrients and fewer calories as they achieve satiety.

To test this logic, we examined whether children would consume fewer calories if they were served 2 types of HND snacks (cheese and vegetables) instead of a NND snack (potato chips) while watching television (TV) cartoons. We examined snack intake during TV viewing to mimic typical snacking contexts as well as to obscure the true purpose of the experiment. Cheese and vegetables were chosen because they are important sources of calcium, protein, vitamins, and fiber that also rank high on the satiety index (ie, required calories for satiety). In addition, children’s intake of cheese and vegetables has been decreasing. We hypothesized that children who ate the combination snack of cheese and vegetables would consume fewer calories than those who ate potato chips. Furthermore, we hypothesized that the effect of the combination snack would be especially pronounced among overweight children, consistent with previous research that overweight children consume more than non-overweight children when provided free snack foods. Finally, we hypothesized that the combination snack would have a more pronounced effect on children from families with lower familial involvement as previous research has found that maladaptive patterns of family mealtime interactions is associated with poor dietary habits. As in previous studies, we focused on overall family involvement during mealtime rather than parental control to examine whether the effect of the combination snack was observed children from low-involvement families. In sum, we tested 4 hypotheses (H) in this research.

H1: Children eating a combination snack of vegetables and cheese will consume fewer calories than children eating chips.

H2: Children eating the combination snack will require fewer calories to achieve satiety than those eating chips.

H3: Heavier children eating the combination snack will consume fewer calories than healthier weight children.

H4: Children from low-involvement families eating the combination snack will consume fewer calories than those from higher-involvement families.

METHODS

Participants were 201 (115 female) children entering the third to sixth grades in the fall of 2011 from the Chicago metropolitan area. A $70 incentive was provided to the parents of participating children. Participants were screened for food allergies to the snacks used in the study. The study had Cornell University’s Institutional Review Board approval, and consent from both the parents and children was obtained before the study.

There were 24 experimental sessions involving 5 to 11 participants. The sessions were conducted in 2 separate rooms, one where children completed the experiment, and the other where parents waited for their children to finish. After arriving, parents were told the study’s purpose was to observe the behaviors of children while watching
TV. Children were told that the study would ask them about characters in popular TV shows and that they would be given snacks to help them enjoy the programs.

Once children arrived and were seated, they were asked to indicate how full they felt (Time 1 Satiety) on 3 hunger-related items: (1) I feel full, (2) I could not eat another bite, and (3) I am hungry; these were measured on 9-point scales (1 = strongly disagree, 9 = strongly agree). We believe that the face validity of the items and the high internal consistency (α = .73) justified the use of this measure.24

Children were then randomly assigned to 1 of 4 snacking conditions, with the snacks being presented on a large plate or tray: (1) potato chips condition (each individual was given plain Pringles/Lays chips in a tube and Crunchy Cheetos in a medium-size bag; ~1500 kcal), (2) cheese-only condition (six 17-g cheese wedges and six 20-g cheese rounds; ~370 kcal), (3) vegetables-only condition (2 cups of uncooked bite-size broccoli, 2 cups of baby carrots, and 2 cups of bell pepper strips; ~120 kcal), and (4) combo condition, cheese and vegetables (six 17-g cheese wedges and six 20-g cheese rounds + 1 cup of each of the 3 vegetables noted above; ~480 kcal). Cheese-only and vegetables-only conditions served as control groups to examine how much children in the combo condition consumed compared with those in control groups. All conditions included more than enough snack food for the duration of the TV programs. They were instructed to snack while watching 2 episodes (~45 minutes in total) of age-appropriate cartoons (eg, SpongeBob). After watching the first episode, children were encouraged to “eat all you wish” of the snacks. They then indicated how full they were on the same scale (Time 2 Satiety). After the second 20-minute episode, snacks were removed. Children were asked how much they liked the episode (1 = hated it; 9 = loved it) and how full they felt using the same scale (Time 3 Satiety). Thus, satiety was measured at 3 time points to determine how their satiety increased. Finally, their age and gender were determined, and their weight and heights were measured to calculate their BMI.

The children were then thanked and reunited with their parents, and questionnaires from both children and parents were collected. Each child’s uneaten food was weighed and subtracted from the weight of the original amount provided to calculate grams consumed.

As the primary dependent variable, grams consumed were converted to calories consumed using the stated caloric values on packaged foods (ie, cheeses and potato chips). For the vegetable snacks, average caloric values per gram were retrieved online at caloriecount.about.com. In addition, we indexed the total calories needed to achieve that level of satisfaction by adopting the satiety index used in previous research.16-18 Specifically, our satiety index was calculated by dividing total calories consumed by the satiety increase from Time 1 to Time 3 to determine how many calories were needed to achieve the level of satiety attained.

The 20-item questionnaire completed by parents concerned the whole family’s mealtime habits by indicating how many days they engage in mealtime activities related to family involvement in a typical week. Specifically, because family involvement is often characterized as the interactions between family members, parents were asked to respond to 3 questions “talk meaningfully about their day,” “compliment each other at dinner,” and “compliment the person who made the dinner.” An exploratory principal components analysis revealed 6 factors with Eigen values > 1 explaining 57.3% of the total variance. The first factor accounted for 20.2% of explained variance consisting of the above 3 questions and 1 item, “eat with the whole family.” We created an index for family involvement by averaging those 4 items, α = .68, such that higher scores indicate higher family involvement.

RESULTS

After excluding data from 18 children who ate no snacks, the 183 remaining participants (104 female) had an average age of 8.7 ± 1.1 years and a mean BMI of 20.3 ± 4.5. The excluded children did not differ from participants in terms of age (8.3 ± 1.1 years) or BMI (19.8 ± 3.8), Ps > .18. Interestingly, the excluded children reported significantly higher baseline satiety (M_satety = 5.35, SD = 2.08) than remaining participants (M_satety = 4.21, SD = 1.38), P = .002. Additionally, they were more likely to be from high-involvement families (M_family = 5.24, SD = 1.36) than remaining participants (M_family = 4.45, SD = 1.32), P = .01. It may be that these children did not eat snacks because they ate regular meals at home and were routinely asked by their parents not to eat snacks outside the home.

According to the Centers for Disease Control and Prevention BMI-for-age growth chart, 38 of the participants were considered overweight (BMI ≥85th percentile), and 43 were considered obese (BMI ≥95th percentile). There was no difference regarding the BMI spread of participants across the 4 conditions (P = .59). There were 45 participants in the potato chip condition, 36 in the cheese-only condition, 59 in the vegetables-only condition, and 43 in the combo condition.
A 1-way analysis of variance (ANOVA) was conducted to examine the effect of the snack conditions on caloric intake. This analysis revealed a significant effect, $F(3, 179) = 95.11, P < .001$ (see the 4 leftmost bars in Fig 1). Pos hoc Tukey’s honestly significant difference tests showed that children who were offered vegetables only ($M_{\text{calories}} = 60, SD = 30$) or cheese only ($M_{\text{calories}} = 200, SD = 90$) ate fewer calories than those in the chip condition, $P < .001$. More important, children offered the combination snack also consumed significantly fewer calories ($M_{\text{calories}} = 170, SD = 70$) than those offered potato chips ($M_{\text{calories}} = 620, SD = 330$), $P < .001$. Children offered the combination snack consumed approximately the same amount of calories as those offered cheese only, $P = .91$, and they consumed significantly more calories than those offered vegetables only, $P < .01$. It is worth noting that children offered the combination snack consumed about the same amount of vegetables as those offered vegetables only (see the 2 rightmost bars in Fig 1).

To examine satiety levels across 3 time points, we conducted a mixed-model ANOVA in which the time was a within-participant factor and the snack condition was a between-participant factor. This analysis revealed a significant main effect for the time, $F(2, 356) = 132.81, P < .001$ (see Fig 2), suggesting a linear increase in satiety. Importantly, this main effect was qualified by a significant interaction effect, $F(6, 356) = 3.41, P = .003$, suggesting that the increases in satiety depended on the condition. A follow-up ANOVA focusing on participants in each condition showed that the effect was strongest among those who ate potato chips, $F(2, 88) = 58.56, P < .001$.

The ANOVA on the satiety index revealed a different picture. Figure 3 illustrates that the effect of the snack condition was significant, $F(3, 171) = 11.68, P < .001$, and post hoc Tukey’s honestly significant difference tests showed that children who ate the combination snack needed significantly fewer calories to achieve satiety ($M_{\text{calories}} = 53.0, SD = 186.4$) than those who ate potato chips ($M_{\text{calories}} = 282.4, SD = 401.9$), $P < .001$. Thus, the combination snack was a more calorie-effective means to attain satiety than potato chips.

Finally, a series of $4 \times 2$ ANOVAs were conducted to examine whether gender, age, BMI, or family involvement moderated the effect of the snack conditions on caloric intake. Because how much they liked the episode did not moderate the effect, we did not explore this factor in this research. Before those analyses, the moderating variables were each divided into 2 groups, male versus female children, children aged $\geq 9$ years versus children ages $<9$ years, overweight or obese children (BMI $\geq 85\text{th}$ percentile) versus healthy-weight children (BMI $<85\text{th}$ percentile), and high versus low in family involvement (median split at 4.5). The analyses revealed significant moderation effects for the children’s weight status, $F(3, 130) = 3.38, P = .02$, and for the family involvement factor, $F(3, 171) = 2.67, P = .049$ (Figs 4 and 5).
The effects of the snack conditions on caloric intake were more pronounced among overweight or obese children and on those from low-involvement families. Overweight or obese children ate more than normal weight children when they were offered chips, but they consumed 16-points fewer (76% vs 60%) calories when the potato chips and combo conditions were compared for each group. Similarly, children from low-involvement families ate more than normal weight children when they were offered chips, but they consumed 10-points fewer (77% vs 67%) calories when the potato chips condition and combo condition were compared for each group.

It is worth noting, however, that those 2 interaction effects were not statistically independent. A 3-way ANOVA
revealed that neither the snack condition × BMI interaction nor the snack condition × family involvement interaction reached conventional levels of significance, *Ps* > .11. Presumably, this reflects the fact that children from low-involvement families were more likely to be overweight or obese; the majority of overweight (55%) and obese (63%) children in our sample were from low-involvement families.

**DISCUSSION**

Children snack more today than they did 30 years ago. With childhood obesity a present and growing problem and NND snacks a factor, strategies for curbing their consumption are needed. This research uncovers several key insights regarding snack substitution. First, a combination snack of cheese and vegetables can be effective in reducing calorie consumption during snacking. Children consumed 72% fewer calories when they were served a combination snack compared with those who were served potato chips. Given that children who were offered cheese only consumed fewer calories than those offered potato chips, simply replacing potato chips with cheese was sufficient to decrease caloric intake. However, it is important to note that the caloric intake of children in the combo condition was not significantly different

**FIGURE 4**

The total caloric intake as a function of weight status and snack condition. The effect of the snack condition was moderated by the weight status, *P* = .02.

**FIGURE 5**

The total caloric intake as a function of family involvement and snack condition. The effect of the snack condition was moderated by the family involvement, *P* < .05.
from the caloric intake of those in the
cheese condition. Children who ate the
combination snack ate approximately
the same amount of vegetables as the
children served vegetables only. This
suggests that the children did not re-
place vegetables with cheese, but
rather, they complemented their vege-
table intake with a source of protein and
calcium. If children were to eat cheese
and vegetables in place of NND snack
foods, snacking could be a good source
of fiber, protein, and calcium. This
observation aligns with the findings of
other studies: the act of snacking can
be associated with reduced obesity
when the snack foods are of the
healthier variety.

Second, children who ate the combi-
nation snack needed significantly fewer
calories to achieve satiety than those
who ate chips. This underscores the fact
that eating snack foods higher on the
satiety index can help reduce caloric
intake. Because no child finished
all the snacks available, we can assume
that they ate snacks until they felt
sated. Those who ate the combination
snack required far fewer calories to
stop snacking than those who ate po-
tato chips.

Third, the effect of the combination
snack on caloric intake was especially
pronounced among those who were
overweight or obese and those from low
involvement families. This means that
the combination snack was an espe-
cially effective means for those who are
most in need of weight reduction and
a healthier diet.

Limitations and Future Research
This research did not examine specific
processes underlying why the combi-
nation of HND snacks led to less
caloric intake compared with the NND
snack. Epstein et al demonstrated the
slower rate of physiological habitua-
tion, decrease in responding (eg,
eating) due to a repeated exposure of
stimuli (eg, foods), when children,
especially overweight children, were
provided with a variety of snacks. Pre-
vious studies have shown that an in-
crease in the variety of foods of-
tered leads to an increase in amount
consumed. This study’s innovation
was the use of that principle to re-
place a single NND snack food with
a variety of HND snacks. Additional
research is needed not only to ap-
preciate the underlying physiological
and psychological processes but also
to compare various combinations of
HND snacks. The impact of combina-
tion snacks on intake over time also
needs to be explored.

Implications
For parents, eliminating snacking al-
together is impractical and, in some
cases, can backfire. However, parents
could potentially replace some NND
snacks with HND snacks such as
a cheese and vegetable combination
with less fear of backlash than if NND
snacks were removed altogether. For
health professionals, the findings of
this research as they relate to family in-
volve could potentially help in
identifying families who might benefit
most from a move toward of “combi-
nation snack substitution.” The link
between HND snacks and satiety can
help dieticians craft diets that allow for
both choice and enjoyment while also
controlling calories.

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**Drug Testing in Middle School:** My four children attended the combined elementary and middle school in our home town. They played soccer, basketball, and lacrosse, and participated in a variety of after-school programs and activities. During the entire time my children were there, approximately 36 school years, never were they asked to submit a urine sample for drug testing. Amazingly, however, drug testing has now seeped into middle school life. According to an article in The New York Times (Sports: September 22, 2012), while the exact numbers of middle schools are hard to calculate, districts in Delaware, Florida, Alabama, Missouri, West Virginia, Arkansas, Ohio, New Jersey and Texas now require drug testing for children in middle school. Drug testing is most often a requirement for students participating in sports or other extra-curricular activities. The testing is designed to find those who are using any types of drugs including alcohol, marijuana, and performance-enhancing drugs. Officials from participating schools report that the majority of parents support the initiative and that drug testing may increase awareness of drug problems and act as a deterrent. Others take a different approach and have filed lawsuits claiming that requiring a middle-school student to submit a urine sample for drug testing before he or she can participate in nonathletic activities infringes on personal liberty. While the Supreme Court has upheld the right of high schools to require drug testing in athletes, whether this extends to students in any extra-curricular activity—particularly those so young—is not known. To date, there are no reports of a middle school child testing positive for performance-enhancing steroids or human growth hormone. Reports of urine samples positive for marijuana are rare. What to do with the test results, whether positive or negative, is often not known. Maybe I am naïve or possibly even nostalgic, but mandatory drug testing of middle school children seems a step too far.

*Noted by WVR, MD*
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