

Citation:

Almiron-Roig E, Flores SY, Drewnowski A. No difference in satiety or in subsequent energy intakes between a beverage and a solid food. *Physiol Behav.* 2004 Sep 30; 82 (4): 671-677.

PubMed ID: [15327915](#)

Study Design:

Non-randomized crossover trial

Class:

C - [Click here](#) for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To compare the relative impact on satiety and energy intakes of the physical form of foods (solid: fat-free raspberry cookies; liquid: regular cola) vs. the timing of consumption (two hours or 20 minutes before lunch).

Inclusion Criteria:

Eligible participants were normal weight (BMI=20-27), were not following a diet to gain or lose weight, did not smoke and consumed breakfast regularly.

Exclusion Criteria:

- Persons with food allergies or food restrictions
- Those who disliked two or more foods or beverages to be served in the study
- Those on prescription medications likely to affect taste, smell or appetite
- Athletes in training
- Pregnant or lactating women
- Persons reporting recent weight loss or weight cycling or those with potential for eating disorders (screened using the Eating Disorder Inventory).

Description of Study Protocol:**Recruitment**

Participants recruited from the University of Washington using advertisements and flyers.

Design

- Non-randomized crossover trial

- Participants consumed equal-energy pre-loads (300kcal) of regular cola (24 ounces) or fat-free raspberry cookies (three ounces) on two occasions each for a total of four separate test sessions that were spaced at least a week apart
- The order of presentation of the four pre-loads was counterbalanced across sessions
- The pre-loads were presented either two hours or 20 minutes before a tray lunch
- The same lunch foods were offered on all four testing occasions.

Dietary Intake/Dietary Assessment Methodology

- All lunch foods were pre-weighed and plate waste was collected and weighed to determine food intake
- Participants were also asked to record all the foods and beverages that they had consumed for breakfast that morning.

Blinding Used

Not specified.

Intervention

Equal-energy pre-loads (300kcal) of regular cola (24 ounces) or fat-free raspberry cookies (three ounces) offered two hours or 20 minutes before a tray lunch.

Statistical Analysis

- Analyses of motivational ratings used a nested repeated-measures ANOVA, with time interval (20 minutes or two hours), physical form (liquid or solid) and time from baseline (Times 1 to 6) as the within-subjects factors and gender as the between-subjects factor
- The effect of baseline hunger on hunger profiles was analyzed using ANOVA, with baseline hunger category (low=ratings 1 to 4 vs. high=ratings 5 to 9) and time (times 1 to 6) as within-subjects factors, and gender as between-subjects factor. When the assumptions of ANOVA were violated, multivariate analysis was used instead
- Analyses of energy and nutrient intakes used a repeated-measures ANOVA, with time interval and physical form as within-subjects factors and gender as the between-subjects factor
- When there was a significant interaction by gender ($P < 0.05$), the data were analyzed separately for each group
- The strength of the association between pre-lunch (Time 6) motivational ratings and energy or water intakes at lunch was tested using Pearson's correlation coefficients
- Palatability ratings ("like") were analyzed using the Friedman test.

Data Collection Summary:

Timing of Measurements

- The study used a within-subject design, with each participant returning for four separate test sessions (two pre-loads and two time conditions)
- The sessions lasted from 9:30 a.m. to 1:00 p.m. and were spaced at least a week apart
- A lunch tray meal was provided at 12:30 p.m. on each occasion.

Dependent Variables

- Ratings of hunger, fullness, thirst and desire to eat using nine-point category scales

- Energy and nutrient intakes at lunch alone, pre-load plus lunch, and breakfast plus pre-load plus lunch
 - Lunch intake measured using pre-weight and plate waste
 - Breakfast intake measured using food records that were verified for completeness by a dietitian.

Independent Variables

Pre-load physical form (liquid or solid) and time interval (20 minutes or two hours).

Control Variables

All participants were asked to report to the laboratory on the same day of the week, to keep evening meals and activity levels on the day before the test as similar as possible, to refrain from drinking alcohol the day before the test, and to have their habitual breakfast on the mornings when they had a test, at approximately the same time.

Description of Actual Data Sample:

- *Initial N*: 32 adults (16 men, 16 women)
- *Attrition (final N)*: All 32 completed the study
- *Age*:
 - Men: 22.8 (4.0) years
 - Women: 23.1 (3.1) years
- *Ethnicity*: Not reported
- *Other relevant demographics*: Not applicable
- *Anthropometrics*:
 - BMI-Men: 22.5 (2.4) kg/m²
 - Women: 21.9 (2.4) kg/m²
- *Location*: United States.

Summary of Results:

Key Findings

- **Hunger ratings**: Repeated measures ANOVA showed significant main effect of time interval [20 minutes vs. two hours; $F(1,30)=29.9$, $P<0.001$]. No main effect of physical form (liquid vs. solid) was detected [$F(1,30)=0.08$; $P>0.05$], and there were no interactions
- **Fullness ratings**: ANOVA showed significant main effect of time interval [$F(1,30)=12.87$, $P<0.01$]. A significant main effect of physical form showed that cola led to higher fullness ratings than did the cookies [$F(1,30)=4.24$, $P<0.05$]
- **Desire to eat ratings**: The effect of time interval [$F(1,30)=24.80$, $P<0.001$] was significant. The desire to eat was not affected by physical form [$F(1,30)=2.06$, $P>0.05$].
- **Thirst ratings**: There was significant main effect of time interval [$F(1,30)=11.23$, $P<0.01$]. Because cola suppressed thirst, whereas cookies did not, the main effect of liquid form was significant [$F(1,30)=62.77$, $P<0.001$]
- **Energy intakes**: Late pre-loads (20 minutes before lunch) were followed by a significantly smaller lunch [$F(1,30)=14.4$, $P<0.01$], suggesting that energy intakes were affected by the time interval between the pre-load and the test meal. In contrast, liquid or solid form had no impact on energy intakes [$F(1,30)=0.04$, $P>0.05$]. The same results were obtained using the

sum of pre-load energy and energy consumed at lunch, or the total amount of energy consumed at breakfast, pre-load and lunch.

Author Conclusion:

- The authors concluded that energy intakes at lunch following the consumption of equal-energy amounts of cola or cookies were not significantly different
- It was the time delay between pre-load and the test meal that affected hunger, satiety and food consumption
- Whether energy is provided in solid or liquid form may be less important than is the time of pre-load ingestion relative to the test meal.

Reviewer Comments:

Although a within-subjects design was used, the order of treatment was not randomized. Rather, the "order of presentation of the four pre-loads was counter-balanced across sessions."

It is unclear if researchers measuring plate waste were blinded to treatment group.

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions

- | | | |
|----|---|-----|
| 1. | Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies) | Yes |
| 2. | Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about? | Yes |
| 3. | Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice? | Yes |
| 4. | Is the intervention or procedure feasible? (NA for some epidemiological studies) | Yes |

Validity Questions

- | | | |
|------|---|-----|
| 1. | Was the research question clearly stated? | Yes |
| 1.1. | Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified? | Yes |
| 1.2. | Was (were) the outcome(s) [dependent variable(s)] clearly indicated? | Yes |
| 1.3. | Were the target population and setting specified? | Yes |
| 2. | Was the selection of study subjects/patients free from bias? | Yes |

2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	Yes
3.	Were study groups comparable?	???
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	No
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	Yes
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	N/A
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	Was method of handling withdrawals described?	N/A
4.1.	Were follow-up methods described and the same for all groups?	N/A
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	N/A
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	N/A
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	Was blinding used to prevent introduction of bias?	???

5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	No
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	???
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	N/A
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were intervening factors described?	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	Yes
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	Yes
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	Yes
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	Were outcomes clearly defined and the measurements valid and reliable?	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes

7.7.	Were the measurements conducted consistently across groups?	Yes
8.	Was the statistical analysis appropriate for the study design and type of outcome indicators?	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	N/A
8.6.	Was clinical significance as well as statistical significance reported?	Yes
8.7.	If negative findings, was a power calculation reported to address type 2 error?	Yes
9.	Are conclusions supported by results with biases and limitations taken into consideration?	Yes
9.1.	Is there a discussion of findings?	Yes
9.2.	Are biases and study limitations identified and discussed?	No
10.	Is bias due to study's funding or sponsorship unlikely?	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes