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Soup preloads in a variety of forms reduce meal energy intake

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INTRODUCTION

Identifying dietary factors that influence energy intake is important for developing effective weight management strategies. The form of food, i.e. solid or liquid, has been suggested to be involved in the regulation of food intake, but the literature on this topic is mixed. Several studies suggest that liquids consumed as beverages are less satiating than solid foods (Bolton, Heaton, & Burroughs, 1981; Dimeglio & Mattes, 2000; Haber, Heaton, Murphy, & Burroughs, 1977), while other studies have found that liquids in the form of soup can be more satiating than solid foods (Kissileff, Gruss, Thornton, & Jordan, 1984; Rolls, Fedoroff, Guthrie, & Laster, 1990a). Several studies have found that eating soup as a preload can decrease hunger, increase fullness, and reduce subsequent test meal intake (Himaya & Louis-Sylvestre, 1998; Kissileff, Gruss, Thornton, & Jordan, 1984; Rolls, Bell, & Thorwart, 1999; Rolls, Fedoroff, Guthrie, & Laster, 1990). However, while it has become clear that consuming soup before a meal can reduce subsequent food intake, few studies have been designed to test whether consuming soup as a preload may help reduce total energy intake (soup + test meal) at the meal. The results from studies that have examined total meal energy intake are varied (Himaya & Louis-Sylvestre, 1998; Kissileff, Gruss, Thornton, & Jordan, 1984; Rolls, Bell, & Thorwart, 1999; Rolls, *et al*., 1997; Rolls, Fedoroff, Guthrie, & Laster, 1990b). In addition, little is known about the specific properties of soup that are involved in reducing food intake and increasing satiety.

Several characteristics of soup have been suggested to be involved in enhancing satiety, including the amount consumed, temperature, fat content, energy content, and viscosity (Kissileff, Gruss, Thornton, & Jordan, 1984; Norton, Anderson, & Hetherington, 2006; Rolls, Fedoroff, Guthrie, & Laster, 1990a; Rolls, Fedoroff, Guthrie, & Laster, 1990b). In addition, the form of soup (the way in which ingredients are blended) may influence energy intake and satiety. Soup form has been investigated in only a few previous studies, and the results from these studies are mixed, suggesting both that the form of soup influences satiety (Himaya & Louis-Sylvestre, 1998; Santangelo *et al*., 1998) and that it does not (Laboure et al., 2002).

The purpose of this study was to examine further the effects of consuming different forms of a low-energy-dense soup as a preload on subsequent test meal intake and total energy intake at the meal (soup preload + test meal). The soups were all prepared from identical ingredients, and included separate broth and vegetables, chunky vegetable soup, chunky-pureed vegetable soup, and pureed vegetable soup. We hypothesized that consuming soup at the start of a meal would decrease subsequent intake and total meal energy intake, compared to when no soup was consumed. We also hypothesized that, based on previous findings, chunky soup would be the most satiating form of soup.

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METHODS

Subjects

Subjects for this study were recruited from a university community by informational flyers, electronic mailing lists, and newspaper advertisements. Individuals who responded to the advertisements were interviewed by telephone to ensure that they met the following criteria: 18 to 45 years of age, not taking medications that are known to affect appetite or food intake, non-smokers, regularly consume 3 meals a day, not dieting to gain or lose weight, not athletes in training, not pregnant or breastfeeding, and free from food allergies and food restrictions. Subjects with a range of ages and body mass indices were recruited in order to extend the relevance of the findings to the general population. Only subjects who reported liking the vegetable soup ingredients, and who were willing to consume the soup, were eligible.

Potential subjects who met these initial criteria came to the laboratory to complete additional screening materials. Included in the screening materials were the Eating Inventory (Stunkard & Messick, 1985), which evaluates dietary restraint, disinhibition, and perceived hunger; the Zung Questionnaire (Zung, 1986), which measures depression; and the Eating Attitudes Test (EAT-26) (Garner, Olsted, Bohr, & Garfinkel, 1982), which assesses attitudes towards food and eating. The Zung Questionnaire (Zung, 1986) and the Eating Attitudes Test (EAT-26) were included in order to ensure that subjects did not exhibit symptoms of depression or disordered eating that might influence food intake and study outcomes. The information collected using the Eating Inventory (Stunkard & Messick, 1985) was to be used in later analyses. Also at this time, trained laboratory personnel took height and weight measurements (model 707; Seca Corp., Hanover, MD, USA). Potential subjects who had a body mass index of 18 to 40 kg/m^2, scored < 40 on the Zung Questionnaire, and scored < 20 on the EAT-26 were eligible for participation in the study. Subjects were told that the purpose of the study was to examine the effects of consumption of various foods and beverages. Subjects gave signed consent and were financially compensated for participation in the study. The study was approved by the Pennsylvania State University Office for Research Protections.

Experimental design

This study used a cross-over design with repeated measures. Subjects came to the laboratory once a week for five weeks, for a total of five test sessions consisting of breakfast and lunch. On each test day, a standard breakfast of bagels and yogurt was consumed *ad libitum* in order to ensure a consistent level of hunger before lunch sessions. Lunch was scheduled at least 3 hours after breakfast. At the beginning of each lunch meal, subjects were served one of four vegetable soup preloads or no preload. Subjects were required to consume the entire preload within a period of 12 minutes; when no preload was served, subjects were asked to sit and read quietly for 12 minutes. The test meal was served 15 minutes after the preload was served. At each meal, the same test meal was served and subjects could eat or drink as much or as little as they wanted. The order of experimental conditions was randomized across subjects.

The sample size to be enrolled in this study was based on previous research with a similar subject population and test meal. According to the power analysis, a sample size of 53 subjects would allow the detection of a 45 kcal (188 kJ) difference in meal energy intake at a significance level of 0.05 and a power of 80%. This represents about 5 to 7 % of typical lunch energy intakes in our laboratory, which was considered to be a clinically significant change.

Foods and beverages

All soup preloads contained the same ingredients (broth, vegetables, and butter) and had the same energy density (0.33 kcal/g; 1.4 kJ/g), but each was prepared using a different method. The ingredients and nutritive properties of the preloads are shown in Table 1. The broth and vegetable preload consisted of a bowl of broth alongside a plate of vegetables in butter. The chunky soup preload consisted of the broth, vegetables, and butter combined into a chunky soup. The chunky-pureed soup preload consisted of the broth, butter, and half of the vegetables blended for 10 sec using a commercial blender (Drink Machine, Model VM0101, Vita Mix Corp., Cleveland, OH, USA), with the remainder of the vegetables added after blending, making a pureed soup containing vegetable chunks. The pureed soup preload consisted of the broth, vegetables, and butter blended together for 15 sec using the same commercial blender. One and a half cups (350 ml) of soup were served to women, and two cups (475 ml) of soup were served to men. All preparation methods were standardized in order to ensure that the preloads were of the same consistency for every subject. The preloads were served in a bowl with a spoon, at a temperature of 65° C.

Viscosity of the liquid component of the soups was measured using an ARES-RFS rheometer (TA Instruments, New Castle, DE, USA). All viscosity measurements were taken at a temperature of 37° C and a rate of 10 s^{-1}. The viscosity of the broth used in the broth and vegetables, as well as in the chunky soup was 0.7 cps, the viscosity of the chunky-pureed soup was 55 cps, and the viscosity of the pureed soup was 235 cps. The size of the vegetable chunks in the chunky and chunky-pureed soup condition was approximately 0.5 $inch^2$.

The test meal consisted of cheese tortellini (460 g for females, 612 g for males; Ralzoni and Bros., Dover, NJ, USA) and tomato sauce (210 g for females, 280 g for males; Campbell Soup Co., Camden, NJ, USA). The test meal was accompanied by parmesan cheese (15 g; Kraft Foods, Inc., Glenview, IL, USA) and a liter of water. The test meal contained 64% of energy from carbohydrate, 16% energy from fat, and 20% of energy from protein, and had an energy density of 2.6 kcal/g (10.9 kJ/g). All foods and beverages served in the study were commercially available. Portions for males and females were based on lunch intake data from previous studies in our laboratory, and provided more energy than most subjects were likely to consume. Pre-determined exclusion criteria were used to identify subjects who ate extreme amounts of the lunch entrée. Subjects who consumed the entire entrée on more than one occasion were excluded from the study.

All foods and beverages were weighed prior to being served to subjects, and were re-weighed after the subjects had finished eating to determine the amount of food and beverage consumed by each subject to the nearest 0.1 g. Energy intakes at each meal were calculated using nutrition information provided by the food manufacturers.

Procedures

On test days, subjects were instructed to consume only foods and beverages provided by the laboratory from the time they woke up in the morning until after the lunch session. Subjects were permitted to consume water between meals until one hour before each test session. Subjects were instructed not to drink alcohol in the 24 hours prior to coming to the laboratory, and not to consume dinner in a restaurant the evening before the test session. Subjects were also told to keep the amount of food eaten and physical activity performed the day before coming to the laboratory as consistent as possible across sessions. They completed a food and activity diary the day before each test session to encourage compliance with this protocol.

On test days, subjects came to the laboratory at their assigned meal times and were seated in individual cubicles. Before each meal, subjects completed a report to evaluate their compliance with the study protocol and to ensure that they were feeling well. At the lunch meal, after the report was completed, the preload was served and subjects were instructed to consume the entire preload within 12 minutes. When subjects received no preload, they were given a magazine and asked to sit quietly and read for 12 minutes. Subjects indicated when they had finished the soup preload, and the empty bowl was removed from the cubicle. If subjects finished their soup in less than 12 minutes, the time taken to consume the soup was recorded and they were asked to sit quietly for the remainder of the 12 minutes. Following the 12 minute preload period, subjects were given 3 minutes to rate hunger and satiety. Then, after a total of 15 minutes, the test meal was served. Subjects were instructed to eat and drink as much or as little of the foods and beverages as they wanted. The amount of time taken to consume the test meal was recorded for each subject.

Ratings of hunger, satiety, and food characteristics

During each test session, subjects completed a series of 100-mm visual analog scales (Hetherington & Rolls, 1987) to assess hunger, thirst, fullness, prospective consumption, and nausea. For example, subjects answered the question “How full do you feel right now?” by marking the 100-mm line anchored by “Not at all full” on one side, and “Extremely full” on the other. Subjects completed these ratings before and after breakfast, before and after the preload time period, and after lunch.

Subjects were also given 100-mm visual analog scales to rate the characteristics of the soup preload and the lunch test meal. Subjects were instructed to first rate the appearance of the preload or test meal, and then take a bite of the preload or test meal and rate the pleasantness of the taste. Subjects also rated perceived calorie content, how filling they thought the preload would be, pleasantness of texture, and thickness of the soup preloads, as well as prospective consumption, perceived calorie content, and portion size of the test meal. For example, subjects recorded their answer to the question “How pleasant is the taste of this food right now?” by marking a 100-mm line anchored on one side by “Not at all pleasant” and anchored on the other side by “Extremely pleasant.” In the condition where vegetables and broth were served separately, subjects were asked to rate each component separately.

Statistical analysis

A mixed linear model with repeated measures was used to analyze the main outcomes of energy intake, food intake (g), ratings of hunger and satiety, and ratings of preload and test meal characteristics (SAS System for Windows, version 9.1; SAS Institute, Cary, NC, USA). The fixed factor effects in the model were preload type and subject sex; awareness of the purposes of the study was also tested as a factor in the model. Analysis of covariance was performed to determine whether subject characteristics affected the relationship between the experimental variables and the main outcomes. Results were considered significant at $p<0.05$.

RESULTS

Subjects

Seventy-three subjects were enrolled in the study; 35 women and 38 men. Based on the previously defined criteria, one woman and five men were excluded for consuming the entire test meal on more than one occasion. In addition, four women and three men were excluded because of non-compliance with study protocol or inability to attend scheduled meals. Thus, a total of 60 subjects completed the study: 30 women and 30 men. The characteristics of these subjects are shown in Table 2.

Food and Energy Intake

Mean entrée intake differed significantly by experimental condition [Table 3]; subjects ate significantly less energy from the test meal when a soup preload was consumed, compared to when no soup was consumed ($p<0.0001$). The different types of soup had no significant effect on intake of the test meal. There was no interaction between condition and sex, indicating that women and men responded similarly to the conditions. However, men had a significantly higher energy intake from the test meal than women ($p<0.001$) [Table 3].

There was a similar pattern of results for total energy intake at lunch (soup and test meal intake combined). Lunch energy intake was significantly decreased when any type of soup was eaten as a preload ($p<0.0001$) [Table 3], compared to when no soup was eaten. Total energy intake at lunch did not vary significantly according to the type of soup eaten [Figure 1]. Subjects reduced total energy intake at lunch by 20% (134 ± 25 kcal; 561 ± 105 kJ) when a soup preload was eaten compared to when no soup was eaten ($p<0.0001$). In addition, subjects consumed a significantly greater total weight of food at the meal when soup was consumed compared to when the test meal was consumed without soup ($p<0.0001$). Therefore, mean total meal energy density was lower when a soup preload was consumed (1.0 kcal/g, 4.2 kJ/g), compared to when no soup was consumed (2.2 kcal/g, 9.2 kJ/g). There were no significant differences in water intake at lunch across experimental conditions (data not shown).

Breakfast intake did not vary by condition. Women ate a mean of 550 ± 15 kcal (2303 ± 63 kJ) and men ate a mean of 694 ± 14 kcal (2906 ± 59 kJ) at breakfast. There were also no differences in the time taken to eat the soup preloads or test meal by soup type. However, men took a significantly longer time to consume their larger portion of soup ($p<0.05$). Women ate the soup in a mean time of 6.9 ± 0.1 min, and men ate the soup in a mean time of 7.8 ± 0.2 min.

Analysis of covariance showed that the relationship between type of preload and energy intake at lunch was not significantly influenced by any of the measured subject characteristics (age, sex, height, weight, body mass index, restraint, disinhibition, or depression).

Ratings of hunger and satiety

Before the preloads were consumed, there were no significant differences in ratings of hunger, fullness, thirst, prospective consumption, or nausea.

Ratings of hunger [Figure 2] immediately before the lunch test meal was served (36 ± 1) were significantly lower when soup had been eaten as a preload, compared to when subjects did not consume soup (65 ± 2, $p<0.001$). Fullness ratings were significantly higher immediately before the lunch test meal was served when a soup preload was eaten (56 ± 1) compared to the no soup condition (26 ± 3; $p=0.04$). Ratings of prospective consumption were significantly lower before the test meal was served when participants ate soup as a preload (40 ± 1) compared to when no soup was consumed (63 ± 2; $p<0.04$). There were no significant differences in ratings of hunger, thirst, fullness, and prospective consumption across the different types of soup at any time point.

After lunch, ratings of hunger, thirst, fullness, and prospective consumption were not significantly different across experimental conditions, although subjects consumed less energy and a greater weight of food when a preload of soup was eaten [Figure 2].

Ratings of soup and entrée characteristics

All of the preloads were rated as acceptable although there were small but significant differences in ratings of soup characteristics according to the type of the preload [Table 4]. Taste ratings were significantly higher for the chunky and chunky-pureed soup compared to the broth and vegetables ($p<0.004$), but varied by only 1 mm. Appearance ratings for the chunky, chunky-pureed, and pureed soup were significantly higher than broth and vegetables, and those for the chunky and chunky-pureed soup were significantly higher than the pureed soup ($p<0.001$). The ratings of calorie content for chunky-pureed and pureed soups were significantly higher than those for broth and vegetables and chunky soup ($p<0.01$). In addition, ratings of thickness varied significantly across soup types; broth and vegetables were rated least thick compared to all other soups, chunky soup was rated less thick than chunky-pureed and pureed soup, and chunky-pureed soup was rated lower in thickness than pureed soup ($p<0.0001$). These ratings of thickness corresponded with the differences in measured viscosity for the soups. Subjects also rated the broth and vegetables as less filling than the other soups, and the chunky soup as less filling than the chunky-pureed, and pureed soup ($p<0.004$). Analysis of covariance showed that the relationship between type of preload and energy intake at lunch was not influenced by any of the soup characteristic ratings.

There were no significant differences in subject ratings of test meal appearance, taste, or calorie content across experimental conditions (data not shown).

Discharge questionnaire

On the discharge questionnaire, 38 subjects (63%) correctly reported that the purpose of the study was to examine the effects of soup on food intake. In addition, 53 subjects (88%) noticed that the type of soup served changed between sessions. However, the mixed linear analysis showed that the primary study outcomes, test meal and total lunch intake, were not significantly influenced by whether subjects correctly or incorrectly ascertained any purposes of the study.

DISCUSSION

Consuming a low-energy-dense soup as a preload led to a significant reduction in test meal intake compared to consuming no soup as a preload. However, the type of soup consumed did not significantly affect test meal intake. Overall, when soup was eaten as a preload, subjects reduced total energy intake at lunch by 20%. This reduction in energy intake was not associated with increased ratings of hunger or decreased fullness at the end of the meal. These results show that consuming low-energy-dense soup in a variety of forms at the start of a meal can reduce subsequent food intake, leading to significant reductions in total energy intake at the meal.

Several studies have established that soup is more satiating than some other types of food. For example, when women and men consumed a preload of soup, subsequent test meal intake was reduced compared to when solid foods, such as cheese and crackers or cantaloupe, were eaten as a preload (Kissileff *et al.*, 1984; Rolls *et al.*, 1999; Rolls *et al.*, 1990a). However, even if consuming a soup preload reduces subsequent test meal intake, it is possible that total energy consumed at the meal (soup and test meal energy combined) may be greater when a soup preload is eaten compared to when no soup is consumed. Few studies have employed a study design that includes a no preload control condition in order to test the effects of consuming soup on total meal energy intake. Of those studies that have, some reported no differences in total meal energy intake with and without a soup preload (Rolls *et al*., 1997, Kissileff *et al*., 1984), while others, including the present study, reported a decrease in total meal energy intake when a soup preload was consumed compared to when no soup was consumed (Rolls *et al.*, 1999; Himaya & Louis-Sylvestre, 1998). These conflicting findings may be the result of variations in preload characteristics, such as volume, energy content, or energy-density, or differences in subject characteristics. In addition, variations in the test meal used to measure subsequent food intake may have affected outcomes; a single-food test meal may be more sensitive to changes in satiety than a mixed-food test meal (Long, Griffiths, Rogers, & Morgan, 2000).

In the present study, the effects of soup form were isolated, and results showed that varying the form of soup by changing the way in which identical ingredients were blended did not significantly affect food intake or satiety. In a similar study, Himaya & Louis-Sylvestre (Himaya & Louis-Sylvestre, 1998) measured satiety in lean and overweight men (N=22) following intake of 300 g (95 kcal; 397 kJ) preloads prepared from identical ingredients: vegetables with a glass of water, chunky vegetable soup, and pureed vegetable soup. In lean men, there were no significant differences between the preloads, while in overweight men, chunky soup significantly reduced lunch intake compared to vegetables with a glass of water. Based on these results, the authors suggested that chunky soup may be the most satiating form of soup. However, it is not clear that simply drinking water along with a food is an appropriate control condition for variations in volume and energy density between preloads. Previous work indicates that water consumed as a beverage has different effects on satiety than water incorporated into a food (Rolls *et al*., 1999; Santangelo *et al*., 1998). For example, drinking a glass of water alongside a casserole was not as satiating as the same ingredients combined into soup (Rolls *et al.*, 1999). This difference in satiety may have occurred because water consumed from a glass was perceived as a beverage intended to satisfy thirst, not hunger. In the present study, instead of separating only the water from the vegetables in the soup, subjects consumed a bowl of broth alongside the vegetables. The separate broth and vegetables had similar effects on satiety as identical ingredients combined into soup. Therefore, differences in ingestion method may explain why the present findings differ from those found in overweight men by Himaya & Louis-Sylvestre; the glass of water may have been perceived as a thirst-quenching beverage, while the bowl of broth may have been perceived as a food that satisfies hunger. These perceptions may have had different effects on food intake and satiety. Further research is needed to determine whether ingestion method and perceptions of a liquid as either a food or a beverage influence food intake and satiety.

There are a number of physiological mechanisms that may be involved in the satiating effects of soup. While liquids empty from the stomach at a faster rate than do solids, viscous solutions with particles of varying size may differentially influence gastric distension and gastric emptying rate (Read & Houghton 1989, Vincent *et al.,* 1995). Increased gastric distension and decreased rate of gastric emptying have been shown to be associated with enhanced sensations of satiety (Geliebter *et al*., 1992). Some studies have shown that consuming pureed tomato soup before a meal can increase gastric distension and decrease the rate of gastric emptying, resulting in increased satiety compared to consuming nothing prior to the meal (Cecil, Francis, & Read, 1998; Spiegel *et al*., 1993). These data suggest that the increased satiety and reduced intake that occurred when the soup preloads were consumed in the present study may have been due to enhanced gastric distension and a decreased rate of gastric emptying.

The effect of the form of soup on physiological responses has also been investigated. One study tested the effects of chunky and pureed soups, prepared from identical ingredients (591g; 499 kcal, 2090 kJ), in men (N=12), and found that while there were no differences in satiety, the pureed soup increased insulin response and energy expenditure compared to the chunky soup (Laboure, Van Wymelbeke, Fantino, & Nicolaidis, 2002). In another set of studies, a pureed vegetable soup (660 g; 615 kcal, 2573 kJ) was found to be more satiating than the same ingredients served as vegetables with a glass of water (360 g + 300ml water; 615 kcal, 2573 kJ) (Peracchi *et al*., 2000; Santangelo *et al*., 1998). The pureed vegetable soup decreased gastric emptying time, increased insulin response, and increased diet-induced thermogenesis compared to the vegetables with a glass of water. Therefore, consuming soup can have gastrointestinal, endocrine, and metabolic consequences that may influence food intake and satiety, and the form of soup may influence these responses. Future work should focus on determining how these various mechanisms combine to reduce food intake and increase satiety.

Increased viscosity has been shown to be associated with increased sensations of satiety and reduced food intake (Hoad *et al*., 2004; Marciani *et al*., 2000; Marciani *et al*., 2001; Mattes & Rothacker, 2001). However, the relationship between viscosity and satiety has been studied primarily using beverages, and few data exist to suggest that varying the viscosity of soup can influence satiety and food intake. The liquid components of the soups used in the present study differed in viscosity, and participants noticed these differences; thickness ratings for the pureed soup were highest, followed by the chunky-pureed soup, chunky soup, and broth and vegetables. Subjects also perceived the thicker soups to be higher in calories and more filling than the less viscous soups. However, neither the variations in viscosity, nor the differences in ratings of thickness, calorie content, or how filling the soups would be, led to systematic differences in subsequent food intake. In particular, the most viscous soup (the pureed soup) did not decrease subsequent intake compared to the less viscous soups. Therefore, our hypothesis that increased viscosity would enhance satiety and decrease total meal intake was not supported. Because the presence of solid vegetable chunks varied along with the viscosity, this study did not isolate soup viscosity as an experimental variable. Interpretation of these findings is also limited due to the likelihood that the effects of increasing viscosity on satiety depend on a number of post-ingestive factors, in addition to the oro-sensory characteristics. Future studies should systematically test how variations in both oro-sensory viscosity and post-ingestive viscosity influence food intake and satiety.

The results from the present study offer additional support for recommending the inclusion of low-energy-dense soup in the diet as a strategy for controlling energy intake for weight management. In this study, subjects ate significantly less total energy and consumed a significantly greater total weight of food at lunch when soup was consumed at the start of a meal. Several studies that have tested the effects of consuming soup on a regular basis for several months found that routinely eating soup can reduce energy intake, enhance satiety, and promote weight loss (Foreyt *et al.*, 1986; Jordan *et al.*, 1981; Rolls *et al.*, 2005). In one dietary intervention, meals that contained soup had fewer total calories than meals without soup, and total daily energy intake was lower when soup had been consumed (Jordan *et al.*, 1981). Taken together, these data suggest that consuming low-energy-dense soup is a strategy that can be used to decrease energy intake and enhance weight loss, while allowing individuals to consume satisfying amounts of food.

The findings from this study confirm previous reports that consuming soup as a preload can significantly reduce subsequent entrée intake, as well as total energy intake at the meal. The present study expanded upon prior investigations to show that varying the form and viscosity of soup, by changing the way in which identical ingredients were blended, did not significantly affect energy intake or satiety. Therefore, consuming a preload of low-energy-dense soup, in a variety of forms, is one strategy that can be used to moderate energy intake in adults.

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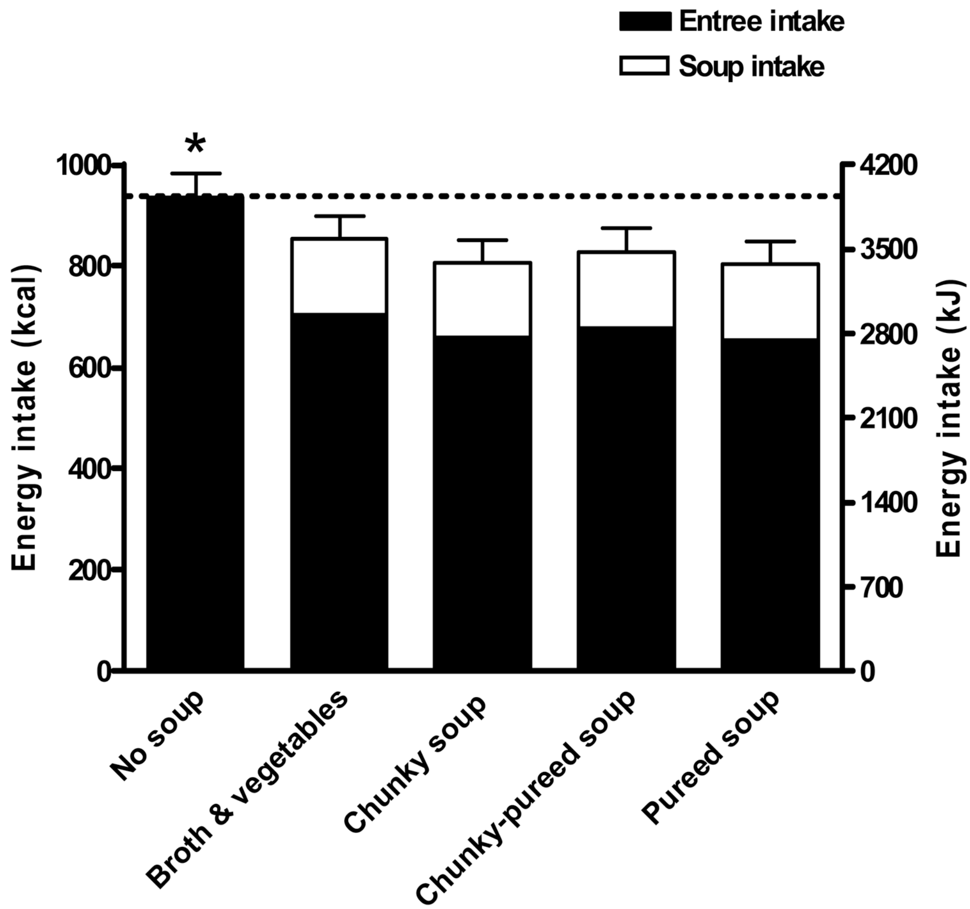

Figure 1.
Mean (± SEM) energy intake at lunch (soup and entrée intake) for women and men combined (n=60). Subjects consumed significantly less total energy at lunch when soup was eaten as a first course, compared to when no soup was eaten *($p<0.0001$).

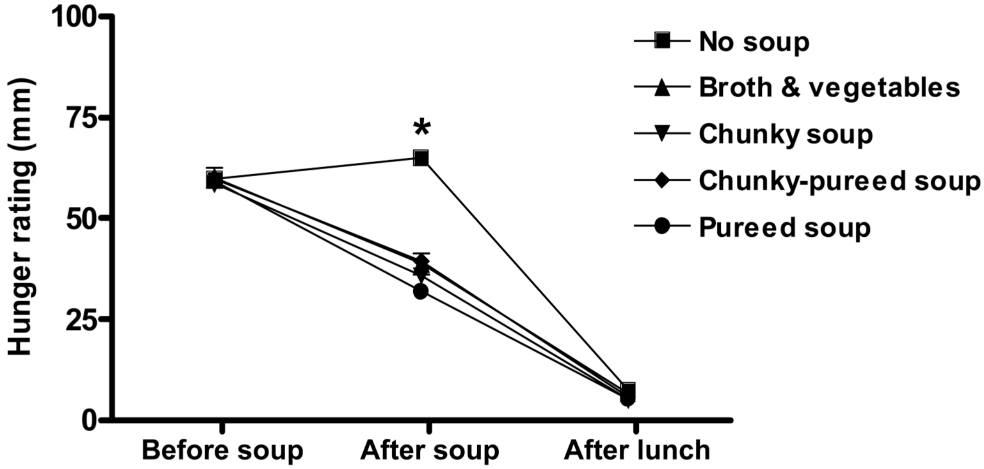

Figure 2.
Mean (± SEM) hunger ratings across the lunch meal for women and men combined (n=60). There were no differences in subjects' hunger ratings "before soup" across experimental conditions. Subjects' ratings of hunger "after soup" were significantly lower when soup had been consumed as a first course, compared to when no soup was eaten *($p<0.001$). There were no differences in hunger ratings "after lunch" across experimental conditions.

Table 1

Nutrient properties of soup preloads served as a first course in a study to test the effects of varying the form of soup on lunch intake

	Amount (g)	Energy (kcal (kJ))	Protein (g)	Fat (g)	Carbohydrate (g)	Energy Density (kcal/g (kJ/g))
Women						
Chicken Broth[1]	220	9 (36)	1	0.5	1	
Broccoli[2]	58	21 (88)	0.7	0	2.7	
Potato[3]	58	50 (209)	1	0	11.6	
Cauliflower[4]	35	8 (33)	0.8	0	1.2	
Carrots[5]	20	8 (33)	0.2	0	1.6	
Butter[6]	4.7	33 (138)	0	3.7	0	
Total preload	**396**	**129 (540)**	**3.7**	**4.2**	**18.1**	**0.33 (1.4)**
Men						
Chicken Broth	293	12 (50)	1.3	0.7	1.3	
Broccoli	77	27 (113)	0.9	0	3.6	
Potato	77	67 (280)	1.3	0	15.4	
Cauliflower	47	11 (46)	1.1	0	1.6	
Carrots	27	11 (46)	0.3	0	2.1	
Butter	6	44 (184)	0	4.9	0	
Total preload	**527**	**172 (720)**	**4.9**	**5.6**	**24.0**	**0.33 (1.4)**

[1] Swanson's Chicken Broth, 33% Less Sodium, Campbell's Soup Co., Camden, NJ, USA

[2] Baby Broccoli Florets, Birds Eye Foods, Inc., Rochester, NY, USA

[3] White potatoes, Sterman Masser Inc. for Foodhold U.S.A., LLC, Landover, MD, USA

[4] Cauliflower Florets, Hanover Foods Corporation, Hanover, PA, USA

[5] Crinkle Cut Carrots, Foodhold U.S.A., LLC, Landover, MD, USA

[6] Salted Sweet Cream Butter, Land O'Lakes, Inc., Ander Hills, MN, USA

Table 2

Characteristics of subjects (n=60) participating in a study to test the effects of varying the form of soup on lunch intake (mean ± standard error; range)

	Females (n =30)	Males (n = 30)
Age (y)	26.9 ± 0.6 (20 – 46)	25.4 ± 0.4 (20 – 39)
Weight (kg)	67.4 ± 0.9 (48.5 – 94.8)	75.3 ± 0.8* (61.2 – 97.5)
Height (cm)	166.9 ± 0.2 (158 – 180)	177.5 ± 0.2* (163 – 189)
Body mass index (kg/m^2)	24.1 ± 0.3 (19.3 – 34.6)	23.9 ± 0.3 (18.8 – 33.4)
Dietary restraint score[1]	8.2 ± 0.4 (1 – 16)	6.4 ± 0.4* (0 – 19)
Disinhibition score[1]	5.8 ± 0.3 (1 – 13)	3.7 ± 0.1* (1 – 8)
Perceived hunger score[1]	4.7 ± 0.2 (0 – 11)	3.9 ± 0.2* (0 – 8)
Eating attitudes score[2]	4.4 ± 0.3 (0 – 19)	3.6 ± 0.3 (0 – 19)
Depression score[3]	28.8 ± 0.4 (22 – 37)	28.9 ± 0.3 (22 – 38)

[1] Eating Inventory (Stunkard & Messick, 1985)

[2] Eating Attitudes Test (Garner *et al.*, 1982)

[3] Self-Rating Depression Scale (Zung, 1986)

[*] Based on the results of a T-test, means differ significantly between sexes (p<0.01)

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Table 3

Intakes of women and men participating in a study to test the effects of varying the form of soup on lunch intake (mean ± standard error).

	Preload condition				
	Broth and vegetables	**Chunky soup**	**Chunky-pureed soup**	**Pureed soup**	**No soup**
Women (n=30)					
Entrée intake					
kcal (kJ)	557 ± 45 (2332 ± 188)	555 ± 46 (2323 ± 193)	580 ± 49 (2424 ± 205)	545 ± 50 (2278 ± 209)	786 ± 47 (3285 ± 197)
g	251 ± 21	250 ± 211	261 ± 22	246 ± 23	356 ± 21
Total lunch intake					
kcal (kJ)	686 ± 45 (2867 ± 188)	684 ± 46 (2859 ± 193)	709 ± 49 (2964 ± 205)	674 ± 50 (2817 ± 209)	786 ± 47 (3285 ± 197)
g	647 ± 21	646 ± 21	657 ± 22	642 ± 23	356 ± 21
Men (n=30)					
Entrée intake					
kcal (kJ)	853 ± 76 (3571 ± 318)	760 ± 68 (3182 ± 285)	804 ± 69 (3257 ± 289)	762 ± 66 (3190 ± 276)	1086 ± 76 (4547 ± 318)
g	380 ± 34	338 ± 30	345 ± 31	341 ± 29	484 ± 34
Total lunch intake					
kcal (kJ)	1025 ± 76 (4291 ± 318)	932 ± 68 (3902 ± 285)	950 ± 69 (3977 ± 289)	934 ± 66 (3910 ± 276)	1086 ± 76 (4547 ± 318)
g	907 ± 34	865 ± 30	872 ± 31	868 ± 30	484 ± 34
All Subjects (n=60)					
Entrée intake					
kcal (kJ)	704 ± 48^{a} (2948 ± 201)	658 ± 43^{a} (2755 ± 180)	677 ± 44^{a} (2834 ± 184)	654 ± 44^{a} (2738 ± 184)	936 ± 48^{b} (3919 ± 201)
g	312 ± 22^{a}	290 ± 19^{a}	299 ± 20^{a}	290 ± 20^{a}	417 ± 22^{b}
Total lunch intake					
kcal (kJ)	855 ± 49^{a} (3580 ± 205)	808 ± 44^{a} (3383 ± 184)	827 ± 45^{a} (3462 ± 188)	804 ± 45^{a} (3366 ± 188)	936 ± 48^{b} (3919 ± 201)
g	774 ± 26^{a}	752 ± 24^{a}	759 ± 24^{a}	751 ± 24^{a}	417 ± 22^{b}

[a,b] Based on the results of a mixed linear analysis, means for a given outcome that have different letters are significantly different (p<0.0001).

Table 4

Ratings of soup characteristics (mm) for subjects in a study to test the effects of varying the form of soup on lunch intake (mean ± standard error)

	Broth and vegetables	Chunky soup	Chunky-pureed soup	Pureed soup
How pleasant is the appearance of this food right now?	23.5 ± 2.5[a]	53.2 ± 3.0[b,c]	53.6 ± 3.0[b,c]	34.8 ± 2.8[b]
How pleasant is the taste of this food right now?	52.7 ± 3.1[a]	61.2 ± 2.8[b]	61.2 ± 2.7[b]	52.0 ± 3.0[a]
How many calories do you think this food has?	25.9 ± 2.5[a]	27.6 ± 1.8[a]	39.0 ± 2.2[b]	36.7 ± 2.6[b]
How filling do you think this food will be?	26.9 ± 3.0[a]	44.1 ± 2.8[b]	57.7 ± 2.5[b,c]	55.5 ± 2.8[b,c]
How thick do you think this food is?	7.9 ± 1.6[a]	31.5 ± 2.7[b]	56.6 ± 2.2[b,c]	62.9 ± 2.8[b,c,d]

[a,b,c,d] Based on the results of a mixed linear analysis, means for a given characteristic that have different letters are significantly different.