Physiology & Behavior 119 (2013) 9–16

Contents lists available at SciVerse ScienceDirect

Physiology & Behavior

journal homepage: www.elsevier.com/locate/phb

Effect of skipping breakfast on subsequent energy intake

David A. Levitsky *, Carly R. Pacanowski

Division of Nutritional Sciences, Cornell University, Ithaca, NY 14853, United States

HIGHLIGHTS

- Two experimental studies examined skipping breakfast on subsequent energy intake.
- Skipping breakfast was not compensated by an increase in intake at lunch.
- Consequently, total daily energy intake was reduced by skipping breakfast.
- Effect was confirmed in a cross-sectional study of non-breakfast eaters.
- Humans do not compensate for variation in energy consumed at previous meals.

ARTICLE INFO

Article history:
Received 14 November 2012
Accepted 3 May 2013

Keywords:
Skipping breakfast
Control of energy intake
Energetic compensation
Weight control
Obesity

ABSTRACT

The objective was to examine the effect of consuming breakfast on subsequent energy intake.
Participants who habitually ate breakfast and those who skipped breakfast were recruited for two studies. Using a randomized crossover design, the first study examined the effect of having participants consume either (a) no breakfast, (b) a high carbohydrate breakfast (335 kcals), or (c) a high fiber breakfast (360 kcals) on three occasions and measured ad libitum intake at lunch. The second study again used a randomized crossover design but with a larger, normal carbohydrate breakfast consumed ad libtum. Intake averaged 624 kcals and subsequent food intake was measured throughout the day. Participants ate only foods served from the Cornell Human Metabolic Research Unit where all foods were weighed before and after consumption.
In the first study, neither eating breakfast nor the kind of breakfast consumed had an effect on the amount consumed at lunch despite a reduction in hunger ratings. In the second study, intake at lunch as well as hunger ratings were significantly increased after skipping breakfast (by 144 kcal), leaving a net caloric deficit of 408 kcal by the end of the day. These data are consistent with published literature demonstrating that skipping a meal does not result in accurate energy compensation at subsequent meals and suggests that skipping breakfast may be an effective means to reduce daily energy intake in some adults.

1. Introduction

Despite many scientific publications demonstrating nutritional benefits of eating breakfast [1,34,55,58,64,65,69,73,80,81,85], skipping breakfast is one of the first changes in feeding habits people make when they want to lose weight [8,12–14,101,104]. About 25% of American adults report regularly not eating breakfast, a statistic that has increased from 14% observed in 1965 [37]. The major reason given for skipping breakfast is to control body weight [78,104].

Skipping breakfast as a means of losing weight appears to contradict the scientific literature. Wyatt and colleagues found that one of the most consistent characteristics of people who were part of the National Weight Control Registry, a group of successful dieters who have maintained at least a 13.6 kg (30 lb) weight loss for one year or more, is that only 4% of the nearly 3000 participants reported that they skipped breakfast, [102] a frequency considerably lower than the 25% observed in the population [37].

Scientific evidence supporting the contention that skipping breakfast is ineffective as a means of restricting energy intake is inferred from the frequently published observation that people who skip breakfast either have a higher Body Mass Index (BMI) or gain weight at a greater rate than people who regularly eat breakfast [2–4,6,7,9,10,12,13,15,16,18,22–26,30,35,40,42,46,47,52,53,56,59,68,70,79,80,82,87,89,90,93–97,100], although there are reports where such relationships were not observed [1,30,31,54,76,83,86,98,99]. Despite the preponderance of studies demonstrating the inverse relationship between BMI and the frequency of eating breakfast, these observations have been correlational. It is equally plausible to interpret these associations as indicating that a high BMI causes one to skip breakfast as it is to suggest that skipping breakfast causes an increased BMI. It is also possible that breakfast eaters engage in other healthy behaviors, such as reduced snacking, lower total fat intake and engaging in regular

* Corresponding author at: 112 Savage Hall.
E-mail address: dal4@cornell.edu (D.A. Levitsky).

0031-9384/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.physbeh.2013.05.006

exercise, all of which will lead to a reduced BMI [38,102]. From this correlational evidence alone, we cannot conclude that eating breakfast results in a reduced BMI or that skipping breakfast results in a higher BMI.

To establish whether skipping breakfast results in an increase in energy intake at succeeding meals to compensate for the lost energy consumed at breakfast requires breakfast consumption to be experimentally manipulated and its effects on resulting intake measured. In one of the few studies that directly tests this idea, Kral and colleagues [57] demonstrated that when children skip breakfast, despite increased hunger ratings, they do not compensate for the caloric deficit by eating more later in the day. To further investigate whether skipping breakfast results in subsequent energetic compensation in adults, the following two experimental studies were performed. The first study examined the effect of skipping breakfast on the amount consumed at lunch. The second study examined the effect of eating a larger breakfast on the amount consumed at lunch and during the rest of the day.

2. Study I

2.1. Material and methods

Participants were recruited from the undergraduate student population at Cornell University through posters and class announcements. The participants were told that the researchers were studying the cognitive effects of breakfast consumption. Volunteers were screened using a health questionnaire and the Stunkard Three Factor Eating Questionnaire. From this pool, twenty-four participants were selected on the basis that (a) they exhibited low restraint scores (<15), (b) they did not have any aversions to the foods that would be served, (c) they were in good physical health (self-report), and (d) they did not take any medications. All participants were between 18 and 23 years old (mean age of 21) with BMIs greater than 20 and less than 25. The study was approved by the Cornell Institutional Review Board.

Participants were divided into three groups matched for age, restraint score, and gender. A randomized cross-over design was used. They were instructed to eat breakfast and lunch in the Cornell Human Metabolic Research Unit (HMRU) on three consecutive Wednesdays. They were instructed not to eat any food after 11:00 pm the night before and to arrive at the Unit between 7:45 and 9:20 the next morning. Depending on which group the participants were assigned, they were given either (a) no breakfast, (b) a high carbohydrate breakfast consisting of a plain bagel with 1½ tablespoons of strawberry or grape jelly and 1 cup of orange or apple juice, or (c) a high fiber breakfast consisting of 1 cup of Raisin Bran cereal with 1¼ cup of 1% milk. The energy content of the high carbohydrate breakfast was 335 kcals and the high fiber breakfast was 338 kcals. The nutrient composition of the two meals is provided in Table 1. The participants were asked to eat all the food given to them. At each testing session one third of the participants received each of the three breakfasts. For each succeeding week, each group was rotated through the remaining treatments according to a balanced Latin square design.

Table 1
Composition of foods consumed at breakfast for Study 1.

Breakfast Study 1	Weight	Calories	Protein	Carbohydrate	Fat	Fiber
High carbohydrate breakfast						
Plain bagel	125	200	12	68	1	1.6
1½ tbs of strawberry or grape jelly	10	25	0	6.5	0	0
1 cup of orange or apple juice	249	110	1	30	0.5	0.3
Total		335	13	104.5	1.5	1.9
High fiber breakfast						
1 cup of raisin bran cereal	56	210	4	45	1.5	6
1¼ cup of 1% milk	305	128	10.3	15	3	0
Total		338	14.3	0	0	6

Table 2
Composition of foods offered at lunch for Study 1.

Lunch Study 1	Weight	Calories	Protein	Carbohydrate	Fat	Fiber
Fruit cocktail	248	181	1.0	46.9	1	2.5
Plain yogurt	245	149	8.5	11.4	8	0
Tuna sandwich	121.8	322	14.2	31.6	0.4	2.3
Turkey sandwich	255	476	23	39	15.6	5
Cheese sandwich	119	399	17.2	30	23.2	1.3
Pasta & marinara sauce	226.8	168	7.2	34	3.2	3.2
Iced tea	226.8	0	0	0	0	0

Participants were not permitted to eat anything between breakfast and lunch. One hour before lunch the participants completed a 6-point hunger rating scale. Lunch was served in the HMRU between 11:30 am and 12:30 pm. When the participants arrived for lunch, they were given a 10 minute paper-and-pencil cognitive test to complete.

Lunch was served from a buffet table (nutrient composition is presented in Table 2). The participants were instructed to eat as much or little as they wanted. After placing each food on separate paper plates, the participants carried the food to a weighing station where the investigators recorded the weight of each item. Data were recorded to the nearest gram. Just before eating, participants completed a second hunger rating scale. After finishing the meal, the amount of food remaining on the plate was recorded. Energy values of the foods consumed were determined from standard food tables [50].

Amount consumed was the major dependent variable of interest. Statistical analyses were performed on both the amount consumed (g) and energy consumed (kcal). The results were identical.

Data were analyzed using a General Linear Model (GLM) with repeated measures in SPSS version 14. Gender, body weight and BMI were included in the model as subject variables. Amount consumed and hunger ratings were dependent variables and the kind of breakfast was entered as the independent variable. The Bonferroni correction was used in the case of multiple comparisons and Tukey's HSD were used to test differences between breakfast conditions.

2.2. Results

Characteristics of the participants are presented in Table 3. Eighteen of the 24 participants were regular breakfast eaters and 19 of the participants were female. Neither gender, body weight, BMI, nor whether or not the participants were regular breakfast eaters had a statistically significant effect on hunger ratings or energy consumption.

Fig. 1 displays the primary outcomes of Study 1. Panel A shows the mean hunger ratings that were taken prior to eating lunch. Skipping breakfast resulted in participants rating themselves significantly more hungry ($p < 0.01$) than after eating either the high carbohydrate or the high fiber breakfast. Consuming either the high carbohydrate or the high fiber breakfast had no significant effect on the participants' ratings of hunger just before lunch. The type of breakfast (high carbohydrate or high fiber) did not have a significant effect on any parameters measured.

Table 3
Study 1 subject characteristics.

Mean age (years)	22.1 ± 2.7
Mean height (m)	1.7 ± 0.08
Mean weight (kg)	61 ± 17
Mean BMI	21 ± 5.2
Female/Male	19/5
Mean restraint score	8.8 ± 0.89
Number of regular breakfast eaters	18/24