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Day-to-day regularity in breakfast consumption is associated with weight status in a prospective cohort of women.

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Abstract

Background: Evidence suggests that regular eating patterns (i.e., consistent day-to-day frequency and timing of consumption) may be favorable with respect to weight status, and breakfast may be a particularly important meal for weight maintenance. We examined the relationship between regular breakfast consumption habits and weight status among women.

Materials and Methods: Modified Poisson regression models examined day-to-day regularity in breakfast consumption among 46,037 women in the prospective Sister Study cohort in relation to weight status. Cross-sectional outcomes included overweight (body mass index (BMI) ≥ 25.0 kg/m²) and obesity (BMI ≥ 30.0 kg/m²); waist circumference (WC) ≥ 88 cm; and waist-to-hip ratio (WHR) ≥ 0.85 . Self-reported weight 5 years post-baseline was used to calculate 5kg weight gain and incident overweight and obesity using BMI.

Results: Compared to women who reported eating breakfast 3 to 4 days/week (irregular breakfast eaters), women who ate breakfast 7 days/week were between 11% to 17% less likely to be obese as measured by WHR (prevalence ratio (PR): 0.89; 95%CI: 0.85, 0.94), WC (PR: 0.85; 95%CI: 0.82, 0.88), and BMI (PR: 0.83; 95%CI: 0.79, 0.87) after multivariable adjustment. Women who never ate breakfast were between 11% to 22% less likely to be obese as measured by WHR (PR: 0.89; 95%CI: 0.83, 0.96), WC (PR: 0.82; 95%CI: 0.78, 0.87), and BMI (PR: 0.78; 95%CI: 0.72, 0.84) compared to irregular breakfast eaters. Prospective analyses showed a 21% and 28% lower risk of 5-year incident obesity among participants who always (relative risk (RR): 0.79; 95%CI: 0.70, 0.90) or never (RR: 0.72; 95%CI: 0.59, 0.87) ate breakfast, respectively, compared to those who ate breakfast 3 to 4 days/week. No association was observed for incident 5kg weight gain.

Conclusions: Results suggest that a regular breakfast consumption habit, comprising eating breakfast every day or never, may be important for maintaining a healthy weight.

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Keywords

overweight; obesity; meal frequency; breakfast skipping; meal pattern; prospective cohort; epidemiology

There is ongoing debate about the optimal number and timing of eating episodes for chronic disease prevention. A statement from the American Heart Association suggested that irregular eating patterns, such as day-to-day inconsistencies in the timing and frequency of meals, may be unfavorable with respect to weight status and cardiometabolic profile.¹ The timing and frequency of meals impact postprandial physiologic responses, for example through varying magnitudes of spikes in glucose.² There is a growing body of literature from randomized trials suggesting the presence or absence of meals (e.g., breakfast) may alter energy balance via subsequent caloric intake, but also through energy expenditure; the latter occurring by alterations in energy utilization,³ changes to thermogenesis during physical activity⁴ or greater participation in physical activity in general.⁵

This relationship between the frequency and timing of consumption with changes in energy balance may be mediated, in part, through circadian rhythms.⁶ Similar to daily exposure to light-dark cycles, food intake is known to entrain clock oscillators in the central nervous system and, in particular, oscillators located in peripheral tissues.⁷ These oscillators are driven by expression of circadian-related genes and feedback from proteins that have downstream effects on many metabolic processes, such as energy utilization (e.g., fat oxidation) and glucose homeostasis, that influence weight status.⁸ Circadian misalignment from irregular day-to-day sleep patterns in the form of shiftwork or social jetlag has been shown to result in metabolic dysregulation, reduced energy expenditure, and subsequently poor weight status.^{9, 10} Therefore, it is plausible that desynchronization of these rhythms from irregular meal consumption may have similar, unfavorable consequences.

Compared to other meal times, breakfast may be particularly important in entraining circadian oscillators. Animal studies have shown that the first meal of the day determines the circadian phases of peripheral clocks, possibly because it is the first meal following a prolonged overnight fast.¹¹ In addition, polymorphisms in circadian-related genes are associated with metabolic syndrome¹² and blunted rhythms of neuropeptides that play a pivotal role in energy regulation.¹³ Thus, irregular breakfast consumption behaviors may alter expression of peripheral clock genes resulting in reduced energy expenditure, poor metabolic health, and obesity.¹⁴

Multiple studies in adult populations have demonstrated an association between breakfast skipping and obesity in comparison to every day or frequent breakfast consumption (e.g. 5–7 days/week), suggesting the importance of breakfast consumption behavior in relation to weight status.^{15–21} However, only one of these studies examined never eating breakfast as a separate category.¹⁶ Based on the hypothesis that regularity in food consumption beneficially influences circadian rhythms, we examined the association between breakfast consumption frequency and weight status with a focus on a regular day-to-day pattern. Multiple criteria were used to define obesity in both cross-sectional and prospective models.

Methods

Study Population

The Sister Study is a large prospective cohort study designed by the National Institute of Environmental Health Sciences to investigate environmental and genetic determinants of breast cancer.²² A total of 50,884 women aged 35 to 74 years who had a sister who was diagnosed with breast cancer but who did not have breast cancer themselves were recruited between 2003 and 2009 from the 50 United States and Puerto Rico. At baseline and after obtaining informed consent, a Computer-Assisted Telephone Interview was completed in addition to a home visit by study staff to collect anthropometric measurements and retrieve self-completed forms, including a questionnaire on dietary intake and patterns. Annual health updates collected information on disease status, and a comprehensive follow-up questionnaire was administered every two to three years. The Institutional Review Board of the National Institute of Environmental Health Sciences and the Copernicus Group Institutional Review Board approved the study. In the present analysis, participants were excluded if they had an extreme body mass index (BMI; <15 or >50 kg/m²; n=303), extreme caloric intake (<500 or >5,000 kcal/day; n=1,595), or if they reported working night shifts at baseline (n=1,430). An additional 1,519 participants were excluded for missing exposure or covariate data, bringing the final analytic sample to 46,037 (Supplemental Figure 1). Participants excluded due to missing data were similar to the analytic sample with respect to caloric intake, physical activity, and various indicators of obesity and abdominal obesity (Supplemental Table 1). Sister Study Data Release 5.0.2 was used in the present analysis.

Meal Consumption Behaviors

A modified version of the 110-item 1998 Block food frequency questionnaire (FFQ) was administered at baseline to assess dietary intakes, with additional questions included to assess meal consumption patterns.²³ Participants were asked, "During the past year, on average, how many days per week did you eat: Breakfast? Lunch? Dinner/Supper?" A similar question asked about snacking at various times of the day. Participants were told to count all beverages as snacks, except for coffee, tea, diet drinks and water. Response categories for all meal consumption and snacking frequency questions were as follows: <1/week, 1–2/week, 3–4/week, 5–6/week, and 7/week.

Adiposity Outcomes

Overweight or obesity status was defined in cross-sectional analyses using BMI, waist circumference (WC) and waist-to-hip ratio (WHR). Trained study staff measured height, weight, and waist and hip circumferences during a home visit at baseline. BMI was used to assess both overweight (< 25.0 kg/m²) and obesity (> 30.0 kg/m²) as binary outcomes.²⁴ In separate models, participants were considered obese if they had a WC ≥ 88 cm or a WHR ≥ 0.85.²⁵ Incident overweight (BMI < 25.0 kg/m²) and incident obesity (BMI > 30.0 kg/m²) were used as outcomes in prospective analyses, along with incident 5kg weight gain. Weight was not measured by an examiner during follow-up, therefore prospective outcomes were calculated using self-reported weight at baseline and self-reported weight from a follow-up questionnaire which was administered 5 years post-baseline.

Statistical Approaches

Modified Poisson regression models were used to estimate prevalence ratios (PR) and risk ratios (RR) for cross-sectional and prospective outcomes, respectively, with corresponding 95% confidence intervals (CI).^{26, 27} Distribution assumptions were valid. Participants who reported eating breakfast 3–4 days/week, i.e. those who had the least regular pattern in breakfast consumption, served as the referent group. Models with incident overweight (BMI 25.0 kg/m²) and incident obesity (BMI ≥30.0 kg/m²) as outcomes were restricted to participants who were normal weight (BMI <25.0 kg/m²) or non-obese (BMI <30.0 kg/m²) at baseline, respectively. The relationship between breakfast consumption frequency and incident outcomes was also evaluated within strata of baseline BMI in a separate analysis. The baseline category of normal weight (BMI 18.5–24.9 kg/m²) was divided into high (22.0–24.9 kg/m²) and low (18.5–21.9 kg/m²) groups to determine if potential associations for incident overweight were driven by smaller gains in weight among women already near the cut point for overweight. A similar approach was taken for models of incident obesity to examine if women who were close to obesity (27.5–29.9 kg/m²) at baseline were driving any observed associations.

All models included adjustment for age, total caloric intake, education, race/ethnicity, physical activity, diet quality (as measured by the Healthy Eating Index (HEI)-2015), smoking status, alcohol intake, average duration of sleep, perceived stress, and participation in a weight loss diet over the previous year. Sleep, an important confounder in the hypothesized relationship between breakfast consumption and weight status, was assessed based on the answer to the following question, “About how many hours and/or minutes of sleep per [night/day] do you get on average?” The HEI-2015 measures adherence to the 2015–2020 Dietary Guidelines for Americans, and is based on 13 different criteria with a range of 0–100.²⁸ Confounders were identified using the prior literature and a directed acyclic graph.²⁹ In a sensitivity analysis, we assessed the potential for mediator bias by removing caloric intake and diet quality as covariates in the modified Poisson models. If there is an indirect pathway between regular breakfast consumption habits and weight status that acts through an association with caloric intake or diet quality, it would be inappropriate to adjust for those variables. All statistical tests were two-sided at $\alpha=0.05$ and all analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC).

A large proportion of the study sample reported participation in a weight loss diet over the 12 months prior to baseline (n=18,098), and in these women, it is possible their weight status influenced their breakfast consumption habits. Therefore, to evaluate the potential for reverse causation, we excluded these women in a sensitivity analysis.

Results

Baseline characteristics, stratified by breakfast consumption frequency, are shown in Table 1. In brief, over half of participants (54%) reported eating breakfast every day, whereas only 5.4% of participants reported never eating breakfast (<1 day/week). On average, women who reported eating breakfast every day consumed the most calories, had the lowest BMI, were most physically active, and most likely to have participated in a weight loss program over the 12 months prior to baseline. Conversely, women who never ate breakfast consumed

the least calories, were most likely to snack after dinner, and had the poorest diet quality (lowest HEI-2015 scores).

Using WC to define obesity resulted in the highest prevalence (40%), while WHR resulted in the lowest prevalence (27%) of obesity at baseline. Self-reported weight after 5 years of follow-up was available for 89% (n=41,154) of the baseline analytic cohort. After 5 years of follow-up, there were 2,383 incident obesity cases.

Compared to the most irregular breakfast pattern (3–4 days/week), reporting never (<1 day/week) or always (7 days/week) consuming breakfast were both inversely associated with overweight and obesity status across all defining criteria, as shown in Table 2. Among the intermediate regularity groups, consuming breakfast 1–2 days/week was also consistently inversely related with weight status (with the exception of WHR), while those consuming breakfast 5–6 days/week were no different than 3–4 days/week with respect to weight status. The strongest associations were observed when using BMI to define obesity ($> 30 \text{ kg/m}^2$), with those who never or always consume breakfast being 22% (PR: 0.78, 95%CI: 0.72, 0.84) and 17% (PR: 0.83, 95%CI: 0.79, 0.87) less likely to be obese, respectively, compared to women who reported eating breakfast 3–4 days/week. Models using WHR as the criteria to define obesity had the smallest estimates of association, although still significant among never consumers (PR: 0.89; 95%CI: 0.83, 0.96) and every day consumers (PR: 0.89; 95%CI: 0.85, 0.94) compared to those who reported eating breakfast 3–4 days/week.

In the prospective analysis (Table 2), participants who never ate breakfast had 26% and 28% decreased risk of 5-year incident overweight (RR: 0.74; 95%CI: 0.62, 0.89) and obesity (RR: 0.72; 95%CI: 0.59, 0.87), respectively, compared to women who reported eating breakfast 3–4 days/week. Similarly, participants who reported eating breakfast every day were at a 12% and 21% lower risk for 5-year incident overweight (RR: 0.88; 95%CI: 0.78, 0.99) and obesity (RR: 0.79; 95%CI: 0.70, 0.90), respectively. Consuming breakfast 1–2 days/week was also inversely associated with incident obesity (PR: 0.75; 95%CI: 0.62, 0.89), but not with incident overweight (PR: 0.91; 95%CI: 0.78, 1.07); no association was seen among those consuming breakfast 5–6 days/week in prospective models. Further, no significant associations were observed for models with incident 5 kg weight gain as the outcome. Participants who were lost to follow-up and therefore excluded from the prospective models (n=4,883) were more likely to have an irregular breakfast habit (consumption 1–6 days/week; 52% vs 40% for those included in the analyses) and had higher average BMI, WC, and WHR at baseline (Supplemental Table 2).

In prospective analyses stratified by baseline BMI (Table 3), among those with a baseline BMI between 18.5 to 21.9 kg/m^2 , participants who never ate breakfast were at a significantly reduced risk of incident overweight BMI (RR: 0.45; 95%CI: 0.20, 0.98). Point estimates were reduced for eating breakfast 7 days a week in this group and for never and ever eating breakfast in women who were heavier at baseline, but confidence intervals contained the null. In models with incident obese BMI as the outcome, point estimates were positive but not significant in the lowest baseline BMI group ($<25.0 \text{ kg/m}^2$), but inverse among the highest BMI group. Specifically, participants with a baseline BMI between 27.5 and 29.9 kg/m^2 who never or always consumed breakfast were 18% (RR:0.82; 95%CI: 0.66, 1.00) or

12% (RR:0.88; 95%CI: 0.79, 1.00) less likely to become obese after 5 years of follow-up, respectively, compared to those who consumed breakfast 3–4 days/week. These results were supported by inverse associations in the high baseline BMI group who never consumed breakfast with a 5 kg weight gain outcome, although results were not significant. In contrast to results for incident obese BMI, however, the low baseline BMI group had non-significant inverse associations with incident 5 kg weight gain in the never or always breakfast consumption groups.

The sensitivity analysis excluding women who reported participation in a weight loss diet showed no indication of bias from reverse causation (Supplementary Table 3). Furthermore, results from models that did not include caloric intake or diet quality as covariates revealed no substantial differences (Supplementary Table 4), suggesting no mediator bias was present.

Discussion

In this prospective cohort of women, a regular day-to-day breakfast consumption habit, comprising either never or always eating breakfast, was inversely associated with obesity when compared to participants with the least regular breakfast consumption habit. The inverse relationship association among individuals with a regular breakfast habit was consistent across multiple criteria for defining obesity in cross-sectional and prospective investigations.

The relative prevalence of obesity was between 9% to 20% lower in participants who never ate breakfast, and 13% to 19% lower in participants who always ate breakfast compared to those who reported eating breakfast about half of the days of the week. In prospective models, multivariable-adjusted results were similar in analyses of incident overweight or obesity, but no association was observed for incident 5 kg weight gain. Furthermore, results were not explained by differences in diet quality or total caloric intake related to breakfast consumption patterns, since these variables were accounted for in all multivariable models, although residual confounding may still be present. In fact, women who consumed breakfast every day had the highest caloric intake and best diet quality, whereas women who never consumed breakfast had the lowest caloric intake and worst diet quality, yet decreased risk of poor weight status was evident in both exposure groups. Results stratified by baseline BMI suggest that a regular breakfast pattern may be beneficial in preventing becoming overweight, particularly when people are thin from the outset. In contrast, a regular day-to-day breakfast pattern appeared to be beneficial in prevention of obesity within 5 years only among those who were already overweight and approaching obesity at baseline. This may be explained by the multifactorial nature of obesity that takes time develop,³⁰ which may not be captured by the present study's duration.

To our knowledge, this is the first population-based study to evaluate breakfast consumption frequency in relation to weight status among adults in such a way that a regular day-to-day pattern may be evaluated. Previous studies investigating frequency of breakfast consumption and weight status have combined 0 days/week with other infrequent categories rather than separately examining the impact of regularly not eating breakfast.^{18, 19, 21} Often, the

exposure was based on a single 24-hour dietary recall,^{15, 20} or a single question about breakfast consumption with a binary response (i.e., do you usually eat breakfast?).¹⁷ A study of breakfast skipping in Japanese adults showed that breakfast skipping was associated with annual increases in BMI, with the highest change in BMI seen in men who eat breakfast 1–3 times/week (0.061 kg/m²/year) compared to men who eat breakfast every day.¹⁶ A smaller change in BMI was observed among men that consumed breakfast 0 days/week (0.046 kg/m²/year). Hypothesis tests were not performed for the comparison of participants who never ate breakfast with participants who infrequently ate breakfast (1–6 days/week), thus rendering it difficult to compare with our results examining the concept of day-to-day regularity. No differences in BMI or WC were observed across breakfast skipping categories in women, and diet quality or weight loss variables were not accounted for in the analysis. One longitudinal study among adolescents showed a significant increase in BMI among never breakfast consumers compared to daily breakfast consumers (2.2±0.2 vs. 1.7±0.17), however results were not significant after inclusion of dieting behaviors in the model, and comparisons were not made with the intermittent breakfast consumption group.³¹

Circadian effects related to breakfast consumption offer a plausible biologic mechanism. Irregularity in sleep, which is a powerful circadian influencer, has been positively associated with obesity independent of sleep duration.^{32, 33} It is hypothesized that desynchronization of central and peripheral clocks and subsequent downstream metabolic effects in energy metabolism serve as a potential mechanism to explain the association. For example, a comparison of night and day shift workers showed that night workers, who have a high occurrence of circadian disruption, had a lower 24-hour energy expenditure.³⁴ As irregular food intake can also induce desynchronization of clocks, it is plausible that the mechanism by which intake influences weight status works through a similar mechanism as sleep irregularity.⁷ A randomized, cross-over trial reported that skipping breakfast had larger adverse effects on insulin and appetite among habitual breakfast eaters than among habitual breakfast skippers, suggesting an adaptation to breakfast skipping.³⁵ Other trials have shown differences in energy expenditure resulting from changes in breakfast consumption frequency, although these differences may vary in lean versus obese individuals.^{4, 5} However, to our knowledge, no studies have looked at differences in energy expenditure across varying degrees of day-to-day regularity in breakfast consumption. Evidence suggests that not all consumption stimuli are equal with respect to changes in circadian rhythms. For example, one study showed that a postprandial change in plasma triglycerides was 50% less pronounced following lunch compared to breakfast, suggesting that breakfast may have a stronger circadian influence than other meals.³⁶ This difference in energy metabolism across meals could explain why consumption behaviors related to breakfast may be most important with respect to weight status.

There are some limitations in our analysis that should be noted, such as self-reported data that may result in misclassification of meal consumption behaviors and covariates. Further, exposure data was only assessed at one timepoint, so it is possible for misclassification to occur if participants changed their behavior during the study period. Use of an FFQ may have resulted in under or over-reporting of caloric intake. While we excluded individuals having implausibly low or high caloric intake (<500 kcal/day, >5,000 kcal/day), substantial misclassification could remain,³⁷ and reporting usual food consumption may be more

difficult for those whose meal patterns were less consistent. The use of caloric cutoffs may have resulted in fewer exclusions than there would be from other methods for excluding caloric intake outliers,³⁸ potentially shifting the overall energy intake estimates downward in our population. Participants were not provided a definition of breakfast; therefore, it is possible their own definition of breakfast differs with respect to caloric intake, time of day, inclusion of beverages which may ultimately affect how many days they reported usual consumption. Although no definition was provided for breakfast, it has been suggested to not impose meal definitions to allow for any cultural differences,¹ although it is reasonable to assume there are minimal cultural differences within our study population as it relates to meal definitions. In addition, questions about specific meals were ordered within structured tables with breakfast listed first, providing a visual clue that breakfast meant the first meal of the day after waking. Self-reported weight at follow-up introduces potential for misclassification of incident outcomes. However, a previous Sister Study analysis indicated the mean absolute difference between self-reported weight at baseline and examiner measured weight was 3.3 pounds,³⁹ therefore we do not anticipate this to have a large effect on our results. We did not have follow-up weight on 10.6% of the population, thus increasing the chance for selection bias. As shown in Supplemental Table 2, those who were lost to follow-up were more likely to have an irregular breakfast consumption habit (consumption 1–6 days/week) but also had higher BMI, WC, and WHR ratio at baseline. Therefore, it is reasonable to expect our results to be attenuated towards the null from selection bias due to their exclusion. There is potential for reverse causality in the cross-sectional analyses and self-reporting of meals may be influenced by those participants who making conscious efforts to lose weight. However, in addition to adjusting for weight loss dieting behavior over the prior 12 months in our main models, we performed a sensitivity analysis excluding these participants and found no substantial differences. Cross-sectional results were supported by results from the 5-year prospective analysis. Residual confounding may be present, as seen by differences in characteristics in the exposure group that never consumed breakfast, however, the Sister Study has detailed information on known confounders which were thoroughly investigated. Results of the present analysis use data collected from a study population of sisters of women diagnosed with breast cancer, thus potentially limiting the generalization of our results. However, prior work has indicated these participants are no more likely to adopt cancer prevention recommendations than the general population and have a similar age- and education-adjusted mean BMI, suggesting they are not more likely to engage in healthy behaviors.⁴⁰

Our analysis has many strengths to offset these minor limitations. Foremost, we have addressed the gap in the breakfast consumption literature through use of a large, prospective cohort of women to evaluate a consistent pattern of consumption, not just any omission of breakfast consumption. Multiple criteria were used to define obesity, and information on many potential confounders allowed us to rule out some other potential explanations for the observed associations, such as differences in diet quality. The use of modified Poisson regression models allowed for estimates of risk, rather than odds ratios, which facilitates interpretation.

In conclusion, the results from the present analysis support the American Heart Association's statement that irregular meal patterns may be unfavorable, and suggest that a

regular day-to-day breakfast pattern, comprising eating every day or never, may be important for maintaining a healthy weight. Moderate benefits may be seen in intermediate consumption regularity categories, such as 1–2 days/week, but it is unclear if intermediate regularity in the form of 5–6 days/week provides any benefit with respect to weight status. The concept of regular meal patterns is underexplored in literature. More studies in other populations are needed to assess the robustness of our results and to evaluate biologic plausibility so that more evidence-based recommendations may be developed to combat weight gain.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations:

BMI	Body mass index
CI	Confidence interval
FFQ	Food frequency questionnaire
HEI	Healthy Eating Index-2015
PR	Prevalence ratio
RR	Risk ratio
WC	Waist circumference
WHR	Waist-to-hip ratio

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Table 1.

Characteristics of study population stratified by breakfast consumption frequency, Sister Study 2003-2009

	Usual Breakfast Consumption Frequency ^a				
	0 day/week	1-2 days/week	3-4 days/week	5-6 days/week	7 days/week
n (%)	2,499 (5.4)	3,297 (7.2)	4,887 (10.6)	10,728 (23.3)	24,626 (53.5)
Age	53.9 ± 8.6	52.3 ± 8.2	52.8 ± 8.5	55.0 ± 8.8	56.5 ± 9.1
Energy intake (kcal/day)	1,494 ± 650	1,544 ± 651	1,606 ± 660	1,594 ± 615	1,658 ± 571
BMI (kg/m ²)	27.4 ± 6.1	28.3 ± 6.3	28.8 ± 6.3	28.3 ± 6.0	26.9 ± 6.5
Waist circumference (cm)	86.0 ± 14.8	87.9 ± 15.0	88.6 ± 15.1	87.7 ± 14.5	84.5 ± 13.9
Waist-to-hip ratio	0.81 ± 0.08	0.82 ± 0.08	0.82 ± 0.08	0.81 ± 0.08	0.80 ± 0.08
MET-hrs/week	48.8 ± 33.5	47.9 ± 31.9	49.7 ± 31.0	50.5 ± 31.0	51.7 ± 31.0
Average sleep (hours)	6.9 ± 1.3	6.9 ± 1.2	6.9 ± 1.2	7.0 ± 1.1	7.2 ± 1.0
Perceived stress (0-16) ^b	3.3 ± 3.2	3.3 ± 3.1	3.2 ± 2.9	2.8 ± 2.8	2.5 ± 2.6
Healthy Eating Index-2015 Score (0-100) ^c	64.8 ± 9.5	65.8 ± 8.7	68.0 ± 8.8	71.1 ± 9.2	74.2 ± 8.8
Reported snacking after dinner 3/week	32.3	28.3	28.4	28.6	31.1
Alcohol use (drinks/day)					
Never/former drinker	20.0	18.4	18.3	19.5	17.9
<1	62.4	66.5	67.0	68.0	68.4
1	17.6	15.1	14.7	12.5	13.7
Smoking status					
Never	41.2	47.8	51.8	56.3	59.6
Former	33.5	33.6	35.1	36.5	36.4
Current	25.3	18.6	13.1	7.2	4.0
Race					
Non-Hispanic White	81.4	77.0	76.0	79.7	90.4
Non-Hispanic Black	10.2	14.5	16.1	12.2	3.2
Hispanic	4.4	5.4	4.8	5.5	4.2
Other	4.0	3.1	3.1	2.6	2.2
Education					
No college	20.7	21.2	17.8	18.4	11.9
Some college	24.2	22.8	23.5	21.7	16.6
College degree or higher	55.1	56.0	58.7	59.9	71.5
Participated in weight loss diet during past year	28.5	31.0	35.0	40.2	42.0

BMI: body mass index; MET: metabolic equivalent of task.

^a categorical variables are reported as column percentage; continuous variables are reported as means with standard error.^b Cohen et al. 1983^c Krebs-Smith et al. 2018

Relationship between regularity in breakfast consumption and cross-sectional and prospectively collected weight status, Sister Study 2003-2015^a

Table 2.

	No. of cases	Usual Breakfast Consumption Frequency				
		0 day/week	1-2 days/week	3-4 days/week	5-6 days/week	7 days/week
<i>Cross-sectional^b</i>						
BMI (kg/m ²)	25	0.85 (0.82, 0.88)	0.93 (0.91, 0.96)	1.00 (ref)	1.00 (0.98, 1.02)	0.90 (0.88, 0.92)
WC (cm)	30	0.78 (0.72, 0.84)	0.93 (0.88, 0.99)	1.00 (ref)	0.99 (0.94, 1.03)	0.83 (0.79, 0.87)
WHR	88	0.82 (0.78, 0.87)	0.92 (0.88, 0.96)	1.00 (ref)	0.99 (0.96, 1.03)	0.85 (0.82, 0.88)
	0.85	0.89 (0.83, 0.96)	0.97 (0.91, 1.04)	1.00 (ref)	0.99 (0.94, 1.04)	0.89 (0.85, 0.94)
<i>5-year incident^c</i>						
BMI (kg/m ²)	25	0.74 (0.62, 0.89)	0.91 (0.78, 1.07)	1.00 (ref)	0.97 (0.85, 1.09)	0.88 (0.78, 0.99)
Weight gain (kg)	30	0.72 (0.59, 0.87)	0.75 (0.62, 0.89)	1.00 (ref)	0.91 (0.80, 1.04)	0.79 (0.70, 0.90)
	5	1.00 (0.90, 1.11)	0.98 (0.89, 1.08)	1.00 (ref)	0.99 (0.92, 1.06)	0.97 (0.91, 1.04)

BMI: body mass index; WC: waist circumference; WHR: waist-to-hip ratio.

^aMultivariable adjustment for age, total caloric intake, education, race/ethnicity, physical activity, HEI-2015, weight loss dieting, smoking, alcohol intake, average sleep hours, and perceived level of stress.

^bPresented as prevalence ratios and corresponding 95% confidence intervals.

^cPresented as risk ratios and corresponding 95% confidence intervals.

Relationship between regularity in breakfast consumption and prospective weight status stratified by baseline BMI, Sister Study 2003-2015^a

Table 3.

Baseline BMI (kg/m ²)	No. of cases	Usual Breakfast Consumption Frequency					
		0 day/week	1-2 days/week	3-4 days/week	5-6 days/week	7 days/week	
<i>Incident BMI < 25 kg/m²</i>							
18.5-21.9	181	0.45 (0.20, 0.98)	0.98 (0.54, 1.79)	1.00 (ref)	1.09 (0.66, 1.81)	0.84 (0.52-1.35)	
22.0-24.9	2,616	0.85 (0.71, 1.01)	0.95 (0.81, 1.11)	1.00 (ref)	0.95 (0.84, 1.07)	0.92 (0.82, 1.03)	
<i>Incident BMI ≥ 30.0 kg/m²</i>							
<25.0	152	1.12 (0.51, 2.45)	1.50 (0.74, 3.08)	1.00 (ref)	1.27 (0.68, 2.37)	1.16 (0.65, 2.10)	
25.0-27.49	545	1.00 (0.68, 1.47)	0.77 (0.53, 1.13)	1.00 (ref)	0.96 (0.73, 1.26)	0.86 (0.66, 1.11)	
27.5-29.9	1,686	0.82 (0.66, 1.00)	0.77 (0.64, 0.93)	1.00 (ref)	0.89 (0.78, 1.02)	0.88 (0.79, 1.00)	
<i>5kg weight gain</i>							
<25.0	2,227	0.88 (0.73, 1.05)	1.07 (0.91, 1.26)	1.00 (ref)	0.90 (0.78, 1.03)	0.92 (0.81, 1.02)	
25.0-29.9	2,421	1.13 (0.90, 1.42)	1.03 (0.84, 1.28)	1.00 (ref)	1.00 (0.86, 1.18)	0.98 (0.84, 1.14)	
30.0	2,159	0.88 (0.67, 1.15)	0.73 (0.56, 0.95)	1.00 (ref)	0.87 (0.72, 1.05)	0.97 (0.82, 1.16)	

BMI: body mass index.

^aReported as risk ratios and corresponding 95% confidence intervals; multivariable adjustment for age, total caloric intake, education, race/ethnicity, physical activity, HEI-2015, weight loss dieting, smoking, alcohol intake, average sleep hours, and perceived level of stress.