Perspectives in Practice

Eating Slowly Led to Decreases in Energy Intake within Meals in Healthy Women

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ABSTRACT

Although reducing eating rate is frequently advocated for control of food intake and thus body weight, empirical evidence is extremely limited and inconsistent. We sought to compare the impact of slow and quick eating rates on development of satiation in healthy women. In a randomized design, 30 healthy women (22.9±7.1 years; body mass index [calculated as kg/m^2] 22.1±2.9) were studied on two test visits to compare slow and quick eating rates. Satiation was examined as the main outcome, using the objective measure of energy intake during ad libitum meals. At designated times, subjects also rated perceived hunger, satiety, desire to eat, thirst and meal palatability on visual analogue scales. Slow rates of ingestion led to significant decreases in energy intake (quick: 645.7±155.9 kcal; slow: 579.0±154.7 kcal; $P<0.05$) and significant increases in water consumption (quick: 289.9±155.1 g; slow: 409.6±205.8 g; $P<0.05$). Despite higher energy intake upon meal completion under the quick condition, satiety was significantly lower than the slow condition ($P<0.05$). Accordingly, the quick condition showed a lower Satiating Efficiency Index (quick: 0.1; slow: 0.2; $P<0.05$). After meal completion, pleasantness ratings tended to be higher under the slow condition ($P=0.04$; but not significant after Bonferroni adjustment). Ad libitum energy intake was lower when the meal was eaten slowly, and satiety was higher at meal completion. Although more study is needed, these data suggest that eating slowly may help to maximize satiation and reduce energy intake within meals.

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Behavioral and nutritional strategies that can help control appetite and energy intake should be developed and tested for their efficacy in body-weight management (1).

Eating slowly is often advised for weight management because slower eating has been hypothesized to allow satiation to register before too much food is consumed (2). Peripheral biomarkers associated with meal termination include physicochemical measures related to stomach distension and responses of several hormones, including cholecystokinin, glucagon-like peptide 1, and ghrelin (3-7). It has been proposed that slower rates of ingestion allow more time for these processes to take place, lengthen satiety's time course, and reduce total energy intake (1,2,8).

Although some findings have associated rapid food ingestion with greater energy consumption (9-11), data on slow eating are very limited and do not fully substantiate its role in satiation (12,13). Animal studies in which eating rate was reduced by increasing time between food items lend support to the hypothesis because increases in meal duration were directly proportional to reductions in food intake (14-16).

Epidemiological studies in Japanese individuals have shown positive association between self-reported eating rates and body mass index (BMI; calculated as kg/m^2), suggesting relevance of this behavior in the prevention of obesity (17-19).

Studies with children and obese adults have asserted the conventional dieting advice to take smaller bites in order to reduce energy intake (20,21). However, eating rate and satiation were not considered in these studies.

In other studies, smaller bite sizes and pauses within ad libitum meals were related with longer meal duration but led to no difference in overall consumption, or were, in fact, associated with less satiation (12,13). These data appear to contradict the idea that slower eating results in reductions in overall intake.

The limited evidence and conflicting findings lend support to the need for additional research in this area. To our knowledge, no study to date has examined the combined recommendation of taking small bites, pausing between bites, and chewing thoroughly. Therefore, the present study investigated the impact of these combined techniques to alter eating rate on satiation and energy intake in healthy females.

METHODS

Subjects

It was determined a priori that 30 healthy females would be recruited from the University of Rhode Island and surrounding area by flyers and classroom announcements. Exclusion criteria included allergies to test foods, caffeine or alcohol dependency, type 1 or type 2 diabetes mellitus, adrenal or thyroid disease, any chronic illness that might cause weight change, clinically diagnosed eating disorders, medications that might alter appetite, and BMI >35. The study was approved by the Institutional Review Board of the University of Rhode Island. Informed written consent was obtained from the subjects but the purpose of the study was not disclosed to them. They were paid for their participation in this three-visit comparative protocol.

Anthropometric Measurements

During visit 1, body weight was measured once in minimal clothing on a digital scale accurate to 0.1 kg (BodPod, Life Measurements Inc, Concord, CA), height was measured once to the nearest centimeter on a wall-mounted stadiometer (Seca 240, SECA, Hamburg, Germany) accurate to 0.1 cm, and BMI was calculated. Waist circumference (cm) was measured once at the level of the umbilicus with a flexible Tyvek measuring tape (SECA). Body composition was assessed after a minimum 2-hour fast by air displacement plethysmography (BodPod) using standardized techniques (22).

Questionnaires

Participants completed a personal health history questionnaire. Eating rate was self-reported as "slow," "medium," or "fast." Two validated instruments, the 51-item Three-Factor Eating and 10-item Herman-Polivy Questionnaires, were also administered to assess levels of dietary restraint, disinhibition, and hunger, as well as chronic weight-focused behavior, respectively (23,24).

Study Protocol

The next two laboratory visits were performed in randomized order to compare experimental conditions 3 to 7 days apart. These second and third visits were conducted during the mid-follicular phase of each subject's menstrual cycle, to control for possible menstrual cycle effects on appetite. Each test visit was conducted with one individual subject at a time.

On the day prior to each test visit subjects were instructed to avoid strenuous physical activity, to refrain from alcohol and caffeine consumption, and to keep diet as close to normal as possible (no extremes of nutrients and calories) and similar on both days.

On the morning of test days, subjects' breakfasts were specifically prescribed and matched between the slow and quick eating conditions. At lunch time, subjects reported to the laboratory, following a minimum 4-hour fast. After voiding their bladders, subjects were offered generous preweighed portions (600 g) of a mixed-macronutrient lunch (described here) and water. They were instructed to consume as much of it as they would like, to the point of comfortable satiation. Under the quick condition, subjects used a large spoon (soup spoon) and were told to consume the meal as fast as possible with no pauses between bites. However, they were instructed to not eat so fast that it was uncomfortable for them. During the slow condition they were instructed to take small bites, put down the spoon between each bite and chew each bite 20 to 30 times. A small spoon (teaspoon) was provided with these meals. During both conditions, investigators carefully monitored the subjects, prompting them to eat according to protocol. Exact clock time of meal initiation and completion was recorded. The amount of the meal and water consumed was calculated by weighed differences (to the nearest 0.01 g) on a digital scale (Adventurer; OHAUS Corp, Pine Brook, NJ).

Assessment of Appetite and Meal Palatability

For both conditions, hunger, satiety, desire to eat, and thirst were assessed with validated 10-cm visual analogue scales (25) before food intake, during the meal every 5 minutes up to 30 minutes, upon meal completion, and at 45 and 60 minutes. Meal palatability was also assessed with visual analogue scales at 1 minute into each meal and after meal completion. These scales were anchored by statements "not at all" and "extremely."

Test Meals

On the morning of the 2 test days subjects were instructed to consume a standardized breakfast at home containing approximately 400 kcal consisting of 8 oz orange juice, 8 oz 1% or 2% milk, and 1 cup ready-to-eat cereal, except granola or Grape Nuts (Post Cereal, Kraft Foods Inc, Northfield, IL), with 8 oz decaffeinated tea or coffee as optional. Subjects consumed identical breakfasts on the morning before each test, and then fasted for a standard time (minimum 4 hours) during which physical activity was minimized. The test meal contained 870 kcal and consisted of ditalini pasta with diced tomatoes with Italian seasoning, celery, and minced garlic sautéed in olive oil, and Parmesan and Romano cheeses. Ditalini pasta was specially chosen because its small size allowed for slow or quick eating rates with small or large utensils. The percent energy coming from carbohydrate, fat, and protein was 48%, 39%, and 13%, respectively.

Statistical Analysis

Main study outcomes were ad libitum energy consumption and ratings of hunger, satiety, desire to eat, thirst, and palatability. All data were entered, double-checked, and managed in Microsoft Excel. Paired t tests were used to compare hypothesis-driven outcomes, including energy intake, total weight consumed, rate of energy consumption, and appetite ratings upon meal completion between quick and slow conditions. For most of these variables comparisons were also conducted between the number of subjects (eg, fast≥slow, slow>fast) using Wilcoxon tests. Additional paired t tests were adjusted for multiple comparisons [Bonferroni adjustment (26)]. Hunger, satiety, desire to eat, and thirst ratings were compared across time points between conditions as repeated measures analysis of variance, time-by-condition interaction, with post hoc comparisons for each time point. Because of the nonlinear nature of the data, different equations (eg, quadratic, cubic) were explored. The equation maximizing the time-by-condition interaction is reported. Results are expressed as mean±standard deviation, and were

Table 1. Age, anthropometric, body composition, and questionnaire results of 30 females participating in the randomized comparative protocol of slow and quick eating

Characteristic	Values
	←mean±standard deviation (range)→
Age (y)	22.9±7.1 (18-48)
Height (m)	1.6±0.1 (1.5-1.7)
Weight (kg)	58.1±8.9 (42.7-85.0)
Body mass index[a]	22.1±2.9 (16.0-31.5)
Waist circumference (cm)	74.7±7.0 (60.0-94.5)
% Body fat	26.5±5.2 (17.1-35.5)
H-P score[b]	11.8±4.4 (0-23)
Dietary restraint score[c]	10.2±5.0 (3-20)
Disinhibition score[c]	6.4±2.6 (2-11)
Hunger score[c]	6.1±2.9 (1-12)
Self-reported eating rate	←n[d]→
Slow	4
Medium	14
Fast	12

[a]Calculated as kg/m^2.
[b]Scores from the Herman-Polivy Questionnaire (H-P). Anchor score: 0-35 (24).
[c]Scores from the Three-Factor Eating Questionnaire. Anchor score: restraint: 0-21; disinhibition: 0-16; hunger: 0-14 (23).
[d]Number of subjects.

considered significant at $P<0.05$, except for tests using Bonferroni adjustments. Data were analyzed using the software Statistica (version 6.1, 2003, StatSoft Inc, Tulsa, OK) and SPSS (version 15.0, 2006, SPSS Inc, Chicago, IL).

RESULTS

Thirty healthy, nonsmoking, premenopausal females were recruited and all completed the study (Table 1). The majority were college students. Only one woman had a BMI > 30 (31.5) and only three had a BMI between 25 and 30. Because their results did not differ from the rest of the subjects, they were included in the analyses.

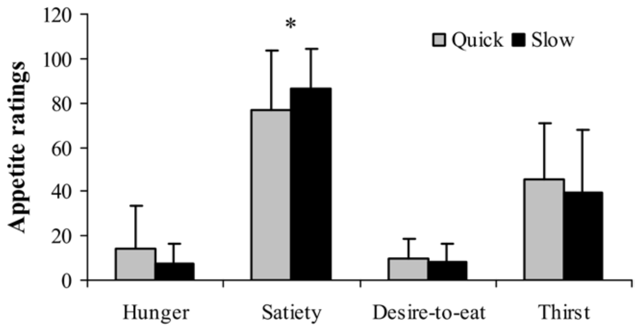

Figure 1. Visual analogue scale appetite ratings (mean±standard deviation) upon meal completion, from 30 women who consumed the identical meal under quick and slow eating conditions, in randomized order. *Satiety ratings were significantly different between conditions (paired t test; $P=0.02$).

Table 2 shows that although meal duration was approximately 21 minutes longer under the slow condition, subjects consumed considerably less energy and weight of food than during the quick condition. No subject consumed the full amount offered under either condition. In contrast, weight of water and total weight consumed were substantially higher in the slow condition than the quick condition. Because of differences in energy and water intakes in both conditions, energy density was considerably lower under the slow condition. The combination of small bites, pauses between bites, and thorough chewing resulted in considerably decreased eating rate, expressed as kcal/min.

Upon meal completion, despite higher energy intake, satiety ratings were significantly lower under the quick condition than the slow ($P=0.02$; Figure 1). Accordingly, the quick condition showed a significantly lower Satiating Efficiency Index (satiety ratings/energy intake [kcal]) (27)

Table 2. Meal's duration, intakes, and eating rate in 30 female volunteers who completed the two experimental conditions (quick and slow)

	Eating Condition		Number of Subjects	
	Quick	Slow	Quick>slow[a]	Slow>quick[b]
	←mean±standard deviation→			
Duration of the meal (min)	8.6±3.1	29.2±8.9[c***]	0	30[d***]
Weight of food consumed (g)	445.3±107.5	399.3±106.7[c**]	25	5[d**]
Energy intake (kcal)	645.7±155.9	579.0±154.7[c**]	25	5[d**]
Weight of water consumed (g)	289.9±155.1	409.6±205.8[c***]	6	24[d**]
Total weight consumed (g)	735.3±210.5	808.9±245.2[c*]	10	20
Energy density (kcal/total g)	0.9±0.2	0.7±0.2[c***]	26	4[d***]
Rate of energy consumption (kcal/min)	84.8±36.2	21.0±7.2[c***]	30	0[d***]

[a]Number of subjects in which meal duration and intakes were higher during the quick condition than the slow.
[b]Number of subjects in which meal duration and intakes were higher during the slow condition than the quick.
[c]Statistical differences between conditions were determined by paired t tests.
[d]Statistical differences between the number of subjects were determined by Wilcoxon tests.
*$P<0.05$.
**$P<0.01$.
***$P<0.001$.

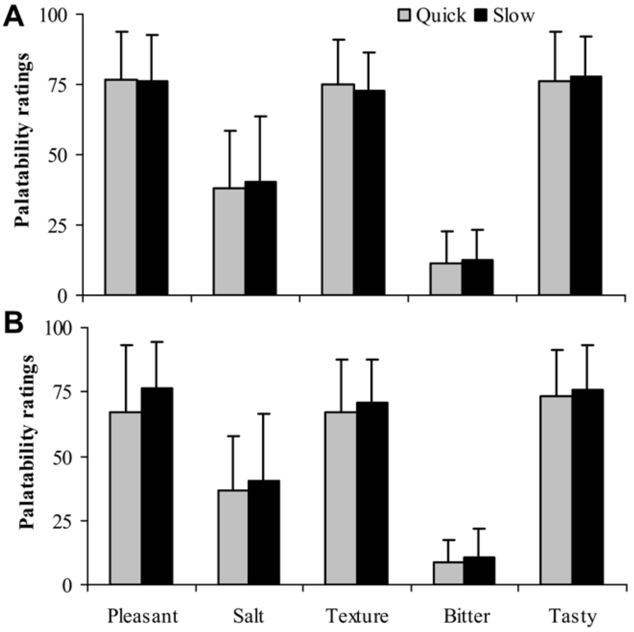

Figure 2. Visual analogue scale palatability ratings (mean±standard deviation), from 30 women who consumed the identical meal under quick and slow eating conditions, in randomized order: (A) 1 minute into the meal; (B) upon meal completion. No significant differences were observed between conditions by paired *t* test after Bonferroni adjustment.

of 0.12±0.05 for the quick condition and 0.16±0.07 for the slow condition ($P<0.01$). Hunger ratings approached significance, being higher upon completion of the meal consumed at a quick pace ($P=0.05$).

No significant differences were observed in palatability ratings between conditions at the meal's beginning ($P>0.05$; Figure 2). However, after meal completion, subjects rated the slow condition more pleasant than the quick (although $P=0.04$, this was not statistically significant after Bonferroni adjustment).

The effect of eating rate on ratings of hunger, satiety, desire to eat, and thirst are represented in Figure 3. The time points of 9 and 29 minutes correspond to average meal termination for the quick and slow conditions, respectively. As shown in Figures 3A and 3B, for all time points 5 to 25 minutes, greater hunger and desire to eat were seen in the slow condition when the subjects were still eating (cubic equation; hunger: F=54.38; $P<0.001$; desire to eat: F=61.06; $P<0.001$). At 30, 45, and 60 minutes, no significant differences in hunger and desire-to-eat ratings were observed between conditions. While subjects were still eating, satiety ratings were lower at 5, 10, and 15 minutes during the slow condition (Figure 3C; cubic equation; F=22.32; $P<0.001$). However, from 20 to 60 minutes there were no significant differences in satiety ratings between conditions. Furthermore, the satiety ratings curve for the slow condition showed a gradual steady increase when compared with quick condition's curve, which increased rapidly during meal intake but leveled off after 9 minutes. Greater thirst ratings were observed for the slow condition than the quick (Figure 3D; quadratic equation; F=7.20; $P<0.01$), with no differences between conditions for any specific time point.

DISCUSSION

This study's results showed that the combined techniques of taking small bites, pausing between bites, and chewing thoroughly can decrease the rate of food ingestion, and enhance effects on satiation, decreasing energy intake.

Several explanations are possible for these observed relationships between slow eating and reduced food intake, all of which need additional investigation, and none of which are mutually exclusive. First, prolonged meal duration can allow more time for physiological satiety signals to develop before too much energy has been consumed. However, empirical evidence must be provided before this reason can be concluded. Secondly, this protocol used combined strategies to slow eating pace, including small bites, thorough chewing, and pausing between bites. Any of these factors, or synergy between them, might have helped the women to consume less and feel more satiated. For example, the process of chewing itself can stimulate physiological satiety signals (28,29). In addition, eating slowly allows time for consuming water along with the meal. Indeed, the women drank more water under the slow condition. Although it is possible that this may have increased stomach distension, and thus induced satiety (3,7), not all studies have shown that water consumed with a meal reduces energy intake (30). Thus, research is underway in our laboratory to clarify this. Finally, eating slowly allows more time for enjoying food, as supported by the pleasantness ratings in this study. It has been suggested that by slowing down and savoring the sight, smell, taste, flavors, texture, and mouthfeel of food, and sensing hunger being suppressed, more satisfaction can result from fewer calories (31,32). However, Kaplan (9) reported that subjects gave higher taste ratings after meals eaten at faster rates as compared with slower rates.

Results of the present study seem to support the previously suggested hypothesis that the physiological feedback from ingested food takes at least 20 minutes to develop, and this delay is independent of the amount of food eaten (2). Our data showed that the extension of meal duration by 21 minutes resulted in 67 fewer kilocalories ingested, and 83% of the subjects consumed a greater amount of energy when they were asked to eat fast. More work is needed to ascertain the physiology behind this.

The present findings expand on a 1980 study (9) that showed a trend toward more food ingestion when subjects decreased pauses between sandwich bites, although it was not clear whether this meant shorter or fewer pauses. In addition, a study in 1991 (8) associated slower eating rates with greater weight loss in obese women during a behavioral weight-control program. However, the authors indicated that the weight loss may be related to a combination of behaviors. Furthermore, two studies have observed positive associations between self-reported eating rates and energy intake as assessed by diet history questionnaires (18,19). Moreover, smaller bite sizes were previously associated with reduced energy intake (20,21), as applies to present findings, yet eating rate was not a factor in these studies.

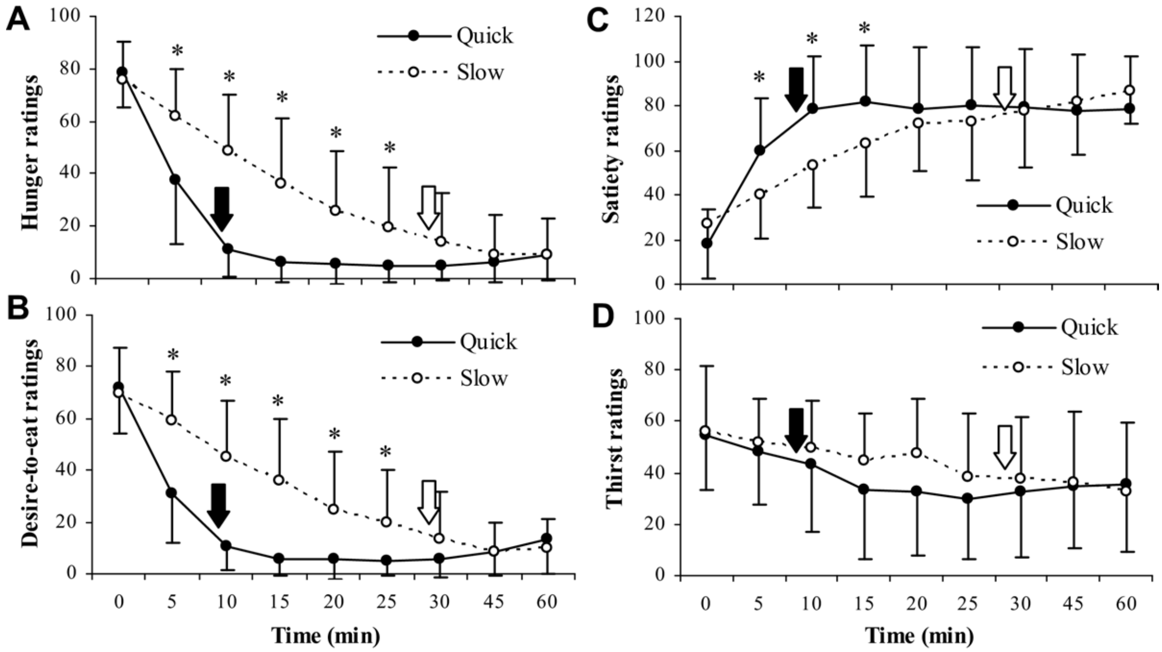

Figure 3. Visual analogue scale appetite ratings (mean±standard deviation) overtime, from 30 women who consumed the identical meal under quick and slow eating conditions, in randomized order: (A) Hunger; (B) Desire to eat; (C) Satiety; (D) Thirst. Closed and open arrows represent meal completion for the quick (~9 minutes) and slow (~29 minutes) conditions, respectively. There were significant time-by-condition interactions with greater hunger (A) and desire to eat (B) in the slow than the quick condition, and greater satiety (C) in the quick than the slow condition, in repeated measures analyses of variance. *Means at a given time point were significantly different between conditions (repeated measures analysis of variance with post-hoc comparisons).

In contrast to the previously mentioned studies, smaller bite sizes (12) or pauses within ad libitum meals (13) led to no differences in general intake and decreased satiation, respectively. The authors suggested that timed pauses during meals are frustrating and that increased intake reflects the subjects' frustration (13). However, food intake was reduced in a preliminary study in which the subjects' eating rate was slowed by having them take mouthfuls upon the beep of a computer (33). The present study, which tested a more natural situation, showed a preference for the slow condition because declines in pleasantness ratings were expressed when subjects consumed the meal quickly, not slowly. Because most subjects reported themselves as medium or fast eaters, it is likely that our combined technique slowed their habitual eating pace. The capacity of individuals to alter their rates of ingestion and its long-range effectiveness and durability, should be examined further, as enquired in previous studies (8,9,19).

As mentioned previously, greater water consumption under the slow condition led to higher total meal weight, which might have induced more stomach distension, and thus satiation. However, this factor reflects the real-life situation, because eating slowly allows more time for water consumption. Moreover, reductions in energy density observed in the slow condition might have affected intake even when fat content was held constant, as shown in previous work (34-36). Nevertheless, drinking large quantities of water at a meal might not necessarily decrease energy intake (30).

Deprivation-induced hunger and meal palatability have both been associated with increased eating rates, higher energy intake, and body size (37,38). In the present study, no differences in appetite ratings were seen in the beginning of the meal, hence the variations in hunger, satiety, desire to eat, and thirst ratings observed afterward resulted from the two different test conditions. Subjects were done eating 646 kcal in <9 minutes, but they ingested 579 kcal during 29 minutes.

In contrast with these findings, greater hunger and lower fullness have been reported at the end of meals with more pauses (13). In another study (9), hunger and fullness ratings before and after the meal revealed no significant differences between two conditions that also differed according to pauses between bites. The present study, which, in addition, slowed eating by smaller bites and more thorough chewing, showed that subjects consumed less energy when they ate more slowly, and rated satiety higher at meal completion.

Additional research is needed to determine how widely these findings can be generalized to other populations, such as males, as it has been suggested that eating rate and its effects differ by gender (19,33,38), or obese individuals, because research regarding distinctive eating style has yielded conflicting results. Previous evidence has suggested that obese individuals eat faster than nonobese (37-40) or has associated faster self-reported eating rates with greater BMI (11,17-19), while other studies found no differences in eating rates between obese and nonobese subjects (9,10,12).

Limitations of this study include the small sample size and limited range of subject characteristics, so more work is needed in larger more diverse samples. Furthermore, it is unknown if the results seen would hold up under different circumstances than these controlled laboratory conditions, with different foods and beverages, or during longer periods of time, so additional study is required to discern this.

CONCLUSIONS

Slow eating decreased ad libitum energy intake in women, and resulted in more satiety after meal completion. Taking small bites, putting down the utensil, and chewing thoroughly may work together to slow eating pace and help to maximize satiation. Thus, these techniques may be recommended to reduce energy intake within meals and therefore manage body weight. Further research is required to examine eating rate's effects on food intake independent of beverage consumption, the effects of eating rate on inter-meal satiety, and to determine if these findings hold true for other populations, and for longer time frames.

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None of the authors have any conflicts of interest.

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