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RESEARCH

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Slowing Bite-Rate Reduces Energy Intake: An Application of the Bite Counter Device

JENNA L. SCISCO, MS; ERIC R. MUTH, PhD; YUJIE DONG, MS; ADAM W. HOOVER, PhD

ABSTRACT

Slow eating may be associated with reduced energy intake. A device that counts bites can provide bite-rate feedback to the user. The purpose of this study was to explore the bite counter's utility for slowing bite-rate and reducing energy intake. The study was a within-participants design with three conditions. From February to April 2009, university students (N=30) ate three meals in the laboratory: a baseline meal without feedback (Baseline), a meal during which participants received bite-rate feedback (Feedback), and a meal during which participants followed a 50% slower bite-rate target (Slow Bite-Rate). Kilocalories of food consumed, ratings of satiation and food-liking, and milliliters of water consumed were statistically compared across conditions using repeated-measures analyses of variance. Overall, participants ate 70 kcal fewer during the Slow Bite-Rate condition compared with the Feedback condition. In addition, when baseline energy consumption was added post hoc as a grouping variable, participants who ate more than 400 kcal at baseline (n=11) ate 164 kcal fewer during the Slow Bite-Rate condition compared to Baseline, and 142 kcal fewer in the Feedback condition compared with Baseline. However, the Slow Bite-Rate condition did not significantly affect participants who ate fewer than 400 kcal at baseline (n=19). Therefore, it seems that slowing bite-rate with the bite counter may be most effective for individuals who consume larger amounts of food. Future research should explore more foods and drinks, more diverse groups of individuals, potential moderating variables, and additional applications of the bite counter.
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J. L. Scisco is a doctoral candidate and E. R. Muth is a professor and Director of Human Factors Institute, Department of Psychology, and Y. Dong is a doctoral candidate and A. W. Hoover is an associate professor, Department of Electrical and Computer Engineering, Clemson University, Clemson, SC.

Address correspondence to: Eric R. Muth, PhD, Department of Psychology, Clemson University, 418 Brackett Hall, Clemson, SC 29634. E-mail address: muth@clemson.edu

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The prevalence of obesity is a primary health concern worldwide (1,2). Obese individuals are at increased risk for many health problems, including hypertension, diabetes, and coronary heart disease (3). Current treatments for obesity include behavioral interventions that focus on changing eating and exercise behaviors via behavioral modifications (4). Our research group has developed a device called the "bite counter" that is capable of detecting when a person takes a bite of food (5), and this wrist-worn device could be used to modify a variety of eating behaviors. In the present study, we examined one potential eating behavior application of the bite counter: slowing bite-rate.

A component of some behavioral treatments for obesity is the reduction of eating rate to decrease energy intake. Statistically significant positive relationships between self-reported eating rate and body mass index (BMI) have been identified (6-10). Some studies have also revealed a link between faster self-reported eating rate and weight gain (7,11). Laboratory studies have shown that obese individuals take larger bites and eat more quickly, and this has been associated with greater food consumption (12-14). However, a slow eating rate intervention has led to decreased food consumption or weight loss (15-17), increased food consumption (18), or no change in food consumption (19,20). In addition, in a laboratory study, Martin and colleagues (16) found that a 50% decrease in eating rate reduced energy intake for men, but not for women.

Therefore, it seems that faster eaters may consume more food and may be more likely to be obese. However, previous research findings do not clearly link a reduction in baseline eating rate to a reduction in energy intake, and it is this relationship that would provide preliminary support for slow-eating training as a component of some behavioral treatments for obesity. In addition, given the novelty of our bite-counter device, previous research has not been able to examine the relationship between bite-rate, energy intake, and obesity.

In the present study, the bite counter device was used to manipulate bite-rate. The bite counter is worn on the wrist like a watch, tracks a pattern of wrist roll motion to detect that the wearer has taken a bite of food, and stores a log of time-stamped bite-count data (5). The device also has the ability to provide real-time bite feedback to the wearer. A bite is operationally defined as food placed on a utensil that is brought to the mouth and consumed. The effectiveness of providing bite-rate feedback, a potential application of the bite counter, was examined in this study. In previous research, reducing eating rate by 50% resulted in decreased energy intake (16). Therefore, it

was hypothesized that a 50% slower bite-rate would reduce energy intake in this study.

Further, baseline energy intake was examined post hoc as a potential moderator of the slow bite-rate and energy consumption relationship. It is possible that the mix of previous research findings on slow-eating manipulations is the result of not identifying important moderators of the eating rate and energy consumption relationship. In particular, baseline energy consumption may moderate this relationship. Slowing eating rate may only be effective for individuals who usually eat more food during a meal compared with individuals who usually eat less food during a meal (16). Therefore, it was hypothesized that the slow bite-rate manipulation would reduce energy intake only for individuals who consumed larger amounts of food at baseline.

METHODS

Participants

Eighty-one university students were contacted as potential participants and were included in the study if they did not have any allergies to the waffle ingredients, reported liking Kellogg's Eggo cinnamon toast waffles (Kellogg NA Co, Battle Creek, MI), typically ate breakfast, and did not have a self-reported eating disorder history. Participants were recruited until the sample was representative of a typical sample of undergraduate students, with 70% normal weight (BMI ≥18.5 and <25) and 30% overweight or obese (BMI ≥25) (21,22).

Thirty-six participants were identified as eligible, and 30 participants completed the study (23 females, 7 males). The participants had a mean age of 19.70 years (standard deviation=3.50, range=18-35). Based on self-reported ethnicity, 26 participants were white, 3 were African American, and 1 was Hispanic. Clemson University's Institutional Research Board for the Protection of Human Subjects approved this study, and all participants signed an informed consent form before participating. Participants received course credit for participation.

Procedure

Participants signed up for the study using an online participant recruitment site. Participants then completed an online prescreening and a laboratory prescreening. The laboratory prescreening was followed by three within-participant laboratory eating sessions: Baseline, Feedback, and Slow Bite-Rate. Each participant was scheduled for a laboratory session no more than 7 days after the previous laboratory session, and laboratory sessions were scheduled at the same time, between 7:00 AM and 11:00 AM, for each individual.

Online Prescreening. When signing up for the study online, the participant first completed an electronic consent form, followed by an electronic prescreening questionnaire and a demographics questionnaire. Eligible participants were contacted by e-mail and phone to schedule the laboratory prescreening. Participants were instructed to refrain from eating, exercising, and drinking liquids other than water for at least 8 hours (an overnight fast) before arriving at the laboratory for their prescreening.

Laboratory Prescreening. The purpose of the laboratory prescreening was to confirm the participant's BMI and measure body fat percentage. After arriving at the laboratory in the morning, the participant first completed a written consent form. The experimenter confirmed that the participant had not eaten, exercised, or consumed any liquids other than water within the previous 8 hours. BMI was calculated from height and weight measured with the Tanita WB-3000 Digital Beam Scale (Tanita Corp, Arlington Heights, IL). Height and weight were measured in the morning with the participant wearing light clothing. Shoes with heels were removed, and shoes without heels were not removed. Body fat percentage was measured using the Omrom Body Logic Body Fat Analyzer (Omron Corp, Kyoto, Japan). The participant was then scheduled for the three laboratory eating sessions.

Baseline Condition. The participants' first meal in the laboratory was the Baseline condition. First, to measure hunger and satiety the participant completed the Satiety Labeled Intensity Magnitude scale (23), a unidirectional hunger visual analog scale (VAS), and a unidirectional fullness VAS.

While the participant completed these scales, three servings of Kellogg's Eggo cinnamon toast waffles (276 g, 870 kcal) were toasted according to package instructions in a separate room. This breakfast food was selected for the present study because it allowed the experimenter to control bite size and easily prepare the food in the laboratory, and pilot testing indicated that the waffles were palatable. In addition, we predicted that these waffles would be familiar to many of our participants. Kellogg's is the leading manufacturer of frozen waffles in the United States (24). Bread-like foods, such as waffles, are eaten by a larger percentage of Americans than any other group of breakfast foods (25), and frozen breakfast foods are increasing in popularity (26).

Each mini-waffle was cut in half, resulting in 72 bite-sized pieces that were served on a plate in this study. The waffles were served with a fork and no knife, and participants did not cut the waffles into smaller pieces. Participants were instructed to eat only one piece of waffle at time; therefore, bite size was controlled. The total amount of food was intended to be more than an individual would eat in one sitting so that they would not have to ask for another serving of waffles.

When cooking was complete, the participant was seated at the eating table, and the plate of waffles was placed on top of a concealed scale in the table and underneath a tablecloth. To measure total grams of food consumed, the Ohaus Scout Pro Balance SP4001 (Ohaus Corp, Pine Brook, NJ) with an RS232 interface sampled the weight of the meal every 3 seconds (the sampling rate of the scale). Data from the scale were collected using TAL WinWedge RS232 data acquisition software (TAL Technologies, Inc, Philadelphia, PA), which imported real-time data into Microsoft Excel (2007, version 12.0.6, Microsoft Corp, Redmond, WA). To collect data for our bite counter development, the participant wore an InertiaCube3 sensor (InterSense, Inc, Bedford, MA) with an attached athletic wrist-band on their dominant wrist and was videotaped during the meal.

The participant was given instructions to eat one piece of waffle at a time until they felt full and told that is was not necessary to eat all of the food on the plate. Five hundred milliliters of water was provided in a glass cup