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Short-term effects of chewing gum on satiety and afternoon snack intake in healthy weight and obese women☆,☆☆

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HIGHLIGHTS

- Gum chewing as a strategy to enhance lunch satiety and reduce afternoon snack intake.
- Subjective satiety was enhanced with gum chewing.
- Highly palatable, high carbohydrate snacks were reduced with gum chewing.
- Gum-associated snack reductions differed between healthy weight and obese women.
- Chewing gum post-lunch may aid in afternoon appetite management for certain snacks.

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ABSTRACT

Afternoon snacking contributes significantly to total energy intake. Strategies to enhance the satiety value of lunch and reduce afternoon snacking are of interest for body weight management.

To assess whether between-meal gum chewing would enhance the satiety response to a fixed lunch meal; and assess the role of cholecystokinin (CCK) as a potential mediator of the response in non-obese healthy weight and obese women.

Fifty unrestrained obese ($n = 25$) and non-obese healthy weight ($n = 25$) women participated in a two-arm cross-over study assessing multiple (15 min per hour × 3 h) gum chewing (GUM) occurrences or no gum (Control) on subjective ratings of satiety, subsequent sweet and salty snack intake, CCK and general metabolic responses.

GUM compared to Control resulted in significant suppression of hunger, desire to eat and prospective consumption ($p < 0.05$). Total snack energy intake was reduced ~9.3% by GUM, but not significantly different from Control ($p = 0.08$). However, overall carbohydrate intake was reduced by GUM ($p = 0.03$). This was consistent with a reduction in snacks characterized as high carbohydrate, low fat ($p = 0.02$). BMI specific effects indicated GUM reduced pretzel intake in obese women ($p = 0.05$) and Oreo cookie intake in healthy weight women ($p = 0.03$) 3 h after lunch. Metabolic responses and CCK did not differ between experimental conditions.

Chewing gum intermittently post-lunch enhances perceptions of satiety and may have important implications in reducing afternoon high carbohydrate-snack intake.

1. Introduction

Satiation and satiety are processes governing food intake behavior and rely on pre-absorptive and post-absorptive signaling to the brain. Pre-absorptive signals originate from the gastro-intestinal tract initiating *generally* with cephalic phase responses to food stimuli. Cephalic phase responses are triggered by sensory properties of food preparing host responses to the incoming energy and nutrient load [1]. Physical properties of food influence the mastication process, which in humans augments the satiety value of the food [2,3,4]. Prolonged chewing of a meal decreased subsequent energy intake [5,6] and increased chewing of almonds was associated with a sustained reduction in appetite ratings 2 h after consumption [7]. Chewing impacts eating rate and also influences gastric emptying rate potentially influencing gastric and intestinal phase satiety responses, suggesting that orally processed

Abbreviations: CCK, cholecystokinin; GUM, gum chewing; HCHF, high carbohydrate, high fat; HCLF, high carbohydrate, low fat; VAS, visual analog scales.

☆ This trial was registered with ClinicalTrials.gov (NCT01316991).

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food would have a greater impact on satiety than food swallowed without mastication [8,9].

In addition to chewing food, there is evidence that chewing gum between eating occasions suppresses appetite and subsequent energy intake [10,11]. Between meals "snacking" contributes significantly to total energy intake for both men and women [12]. From a therapeutic perspective, these data suggest that gum chewing could serve as a strategy for appetite and food intake control between meals possibly aiding in body weight management. However, research findings with gum chewing have not been consistent [13]. This may be due to differences in populations studied and/or study design variance. Indeed, further research is required to understand the role of gum chewing in energy intake regulation.

The goal of the present study was to expand upon current published knowledge focusing attention on women and the use of gum chewing to enhance satiety and appetite control post-lunch, a time when snacking occurs most frequently and when taste trumps nutritional quality [14]. Among adult women, high-carbohydrate, high-fat snacks are preferred and intake correlates with increased total daily energy intake [12]. Further, the impact of chewing gum between meals may differ between non-obese healthy weight and obese women. Previous work has shown that obese individuals have altered satiety responses compared to non-obese individuals [2,15,16], which may drive greater interest in snacking behavior. Obese individuals also have been shown to chew less and have a faster eating rate than non-obese individuals [17]. Likewise, obese individuals have been shown to have blunted satiety peptide responses to meals [18,19], including variability in cephalic phase reflexes to food stimuli compared to healthy weight individuals [20,21]. Considering the role of mastication/chewing in food-associated satiety, we hypothesized that by extending the act of chewing post-meal, while food was in the gut, the satiety value of the meal would be enhanced reducing afternoon snack intake. Further, we hypothesized the effect would be more pronounced in obese women, possibly through resolving blunted obesity-related satiety peptide secretion.

Cholecystokinin (CCK) is a putative satiety peptide secreted from I-cells concentrated in the upper small intestine in response to food stimuli [22,23]. CCK has been shown to be sensitive to changes in dietary input, particularly in women correlating with subjective satiety [24,25,26]. Further, CCK has been shown to be more likely to have an individual role in satiety than other satiety peptide, such as peptide YY (PPY) and glucagon-like peptide-1 (GLP-1) [27]. For these reasons, and because CCK secreting cells are ideally located for sensing subtle physiochemical changes in intestinal contents due to altered oral or gastric phase responses, CCK was chosen as the satiety peptide to monitor for its possible involvement in gum-related post meal enhanced satiety.

Therefore, the present study aims to characterize the subjective-, behavioral- and biological- satiety responses of healthy weight and obese women after a fixed lunch meal with and without periodic gum chewing. The overarching hypothesis is that gum chewing will enhance the satiety value of a fixed lunch meal by suppressing motivation to eat highly palatable snacks mid-afternoon and that the effects will be described at least in part by enhanced CCK secretion. Due to the blunted satiety responses typically observed in obese individuals, we also hypothesized that gum chewing would be restorative and enhance satiety to a level not different than healthy weight women.

2. Material and methods

The study was conducted according to good clinical practice guidelines and approved by the Illinois Institute of Technology (IIT) Institutional Review Board. All subjects reviewed and signed an Informed Consent Form approved by the Institutional Review Board prior to screening. This trial was registered with ClinicalTrials.gov (NCT01316991) and was performed at the Clinical Nutrition Research Center (CNRC) at the Illinois Institute of Technology, Chicago, Illinois.

2.1. Study design and participants

The study was designed as a randomized, 2-arm, within-subjects crossover to test the effects of gum chewing vs no gum chewing after a fixed lunch meal on post-meal subjective satiety and subsequent snack intake in healthy weight and obese women. Women were recruited from the greater Chicago, IL area through online advertisements, university community flyers and word of mouth. Eligible women were required to be in generally good health, 18 years of age or older, unrestrained (score of ≤12 on Factor 1 of the Three Factor Eating Questionnaire [28] and with body mass index (BMI) between 18.5 and 24.9 kg/m^2 or 30–38 kg/m^2. Exclusion criteria were set as follows: Individuals with clinical evidence and/or history of cardiovascular, respiratory, renal, gastrointestinal, metabolic or hepatic disease/conditions, who use prescription and/or over the counter medications that may interfere with study endpoints (e.g. appetite suppressants), smoke, have measured fasting glucose > 110 mg/dL, self-described unusual dietary habits (e.g., pica), who were actively losing weight or self-reported illicit drug use and/or alcohol use > 5 servings per day on a subject characteristics questionnaire or who showed signs of depression (score of >50 in Depression Index [29]). Ninety-eight women passed an initial online or phone screening and were invited for an in-lab eligibility assessment. Fifty-seven women passed the in-lab screening and were invited to participate in the study. All 57 women agreed and were enrolled in the study. Four women dropped out of the study early due to vein inaccessibility to take blood and 3 women dropped out due to time conflicts. A total of 50 subjects completed the study.

2.2. Treatment, preload meal and test snacks

The treatment intervention was chewing gum (sugar-free peppermint flavored stick chewing gum, Wrigley Jr. Co., Chicago, IL) that was provided to women participants at defined intervals after lunch: 1 stick 15 min every hour over 3 h period (3 sticks total). The control arm was no gum. During the gum chewing condition, women chewed gum during the last 15 min of each hour (45–60, 105–120 and 165–180 min post-lunch), which was just before a blood draw. The fixed lunch was a pasta and salad meal prepared from commercially available ingredients providing ~500 cal and 62%, 27%, 10% of kcals from carbohydrate, fat and protein, respectively. Following the blood draw at 180 min, a combination of 4 different "test" snack items were provided in individual bowls on a tray for participants to eat as much or as little as they wanted. Snacks were categorized as sweet or salty and were high carbohydrate-low fat or high carbohydrate-high fat. Snacks were: Skittles® (Wrigley) (sweet, high carbohydrate-low fat), Nabisco Oreo sandwich cookies-chocolate (sweet, high carbohydrate-high fat), Rold Gold pretzels classic pretzel thins (salty, high carbohydrate-low fat) and Lay's potato chips classic (salty, high carbohydrate-high fat). The tray contained approximately 1235 kcal. All foods and drinks were purchased from the local supermarket and prepared in the CNRC metabolic kitchen and dispensed using safe food handling procedures.

2.3. Procedures

Participants visited the clinical facility on 2 different occasions for testing. Subjects were asked to maintain usual dietary and exercise habits, including eating similar (usual) meals the night before and the morning of each study visit. To facilitate compliance, subjects met with a Registered Dietitian (RD) for guidance and completed detailed 24 h scale-weighed food records 3 days before, the day before and on each study day test session.

On the day of each study session, subjects arrived to the laboratory ~30 min before their usual lunch time, which corresponded to ~3.5 h between breakfast and lunch. Upon subjects' arrival to the clinical laboratory, body weight, blood glucose, hunger level (using 100 mm visual analog scale) and food records were checked to protocol compliance