



Review

Large portion sizes increase bite size and eating rate in overweight women



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HIGHLIGHTS

- Increasing the portion size of a meal is associated with marked changes in eating behavior.
- Average bite size increased by 0.22 g for every 100 g increase in portion size.
- Larger portions led to an increase in eating rate up to about 540 g.
- Meal duration increased by 22.5% for every 100 g increase in portion size.
- Reducing bite size and slowing eating rate may reduce the risk of overconsumption.

ARTICLE INFO

Article history:

Received 4 June 2014
Received in revised form 10 November 2014
Accepted 12 November 2014
Available online 18 November 2014

Keywords:

Portion size
Bite size
Eating rate
Meal microstructure

ABSTRACT

Objective: Larger food portions lead to increased intake but the mechanism behind this effect is unclear. We investigated the effect of portion size on bite size, eating rate, deceleration rate, and meal duration.

Design and methods: Thirty-seven overweight women attended 5 visits after a 3 h fast and consumed a 229, 303, 400, 529 or 700 g portion of a lunch meal in random order. Meal eating parameters were measured with the Sussex Ingestion Pattern Monitor. Data were analyzed with mixed effects models.

Results: Average bite size increased by 0.22 g for every 100 g increase in portion size ($p = 0.001$); portion size had a non-linear effect on eating rate, increasing with portion sizes up to about 540 g ($p = 0.01$). Deceleration rate (reduction in speed of eating) decreased by 20% ($p < 0.001$) and meal duration increased by 22.5% for every 100 g increase in portion size ($p < 0.001$), relative to the smallest portion.

Conclusions: Increasing portion size led to a larger bite size and faster eating rate, but a slower reduction in eating speed during the meal. These changes may underlie greater energy intakes with exposure to large portions. Interventions to reduce bite size and slow eating rate may provide individuals with strategies to reduce the risk of overconsumption.

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1. Introduction

Exposure to larger portion sizes has been linked with increased intake both in children and adults, and across a variety of foods and settings [1,2] although, the mechanisms underpinning this effect are unclear. Secular increases in portion sizes of many foods mean that individuals may need to develop personal coping strategies to avoid overeating. Understanding the factors associated with overeating in the face of larger portions may help to develop weight management interventions.

The microstructure of meal eating (the behavioral components associated with eating, including bite size, eating rate, meal duration, and the reduction in eating rate, also known as deceleration rate) is of increasing interest in the attempt to identify targets for interventions to constrain energy intake. Previous work has suggested that larger portions lead to an increase in bite size [3–5], as people increase the amount on their utensil in response to larger amounts on the plate [5]. A recent systematic review of controlled laboratory studies has shown that a faster eating rate is associated with greater energy intake [6]. Some of these parameters are inherently linked, for example, eating rate is affected by bite size [7,8], which is associated with the amount of food eaten [3,9].

Current evidence on how portion size affects eating behavior microstructure is limited to observing the number of bites in order to estimate bite size [5] but modern technology now allows the precise measurement of bite size and other related parameters [10]. The current study tested the hypothesis that increasing the portion size of a meal would lead to an increase in bite size. Secondary objectives were to explore changes in overall eating rate, deceleration rate and meal duration. We focused on overweight women only to make our sample more homogeneous especially as the portion size effect may differ across genders [11,12].

2. Methods and procedures

2.1. Participants and recruitment

Healthy women aged 18–60 years with a BMI between 25 and 35 kg/m² were recruited from Cambridge and surroundings. As eating behavior microstructure parameters may differ between males and females [13] only women were recruited to reduce heterogeneity. It was estimated that 35 women were required to achieve 90% power (at a significance level of 0.05) to detect a 2.4 g difference in average bite size when portion size is doubled [5], assuming a standard deviation within-subjects (women) of 3 g/bite [13]. To account for possible drop outs, 40 women were recruited.

To avoid alterations in normal eating behavior due to knowledge of the true study aims, the study was advertised as “investigating the influence of the eating environment on meal satisfaction”. Exclusion criteria included: smoking; currently dieting; consuming breakfast less than 5 days per week; being pregnant, planning a pregnancy or breastfeeding; disliking or restricting of the test foods (e.g. vegetarianism, food allergies); presence of an eating disorder, defined as a score ≥ 11 on the Eating Attitudes Test (EAT-26) [14,15]; having a medical condition (e.g. gastro-intestinal disorders) or taking medication

(e.g. antidepressants) that can affect appetite; self-reported depression, mental illness or psychiatric disorder; excessive alcohol intake (> 14 units/week); and performing ≥ 10 h/week intense physical activity. Weight and height were recorded at a screening visit with a SECA scale and stadiometer to the nearest 0.1 kg and 0.1 cm respectively, from which BMI was calculated. Candidates completed the EAT-26 questionnaire. Those meeting eligibility criteria for BMI and EAT-26 scores were asked to attend a training session.

2.2. Measurement of eating behavior parameters

The Sussex Ingestion Pattern Monitor (SIPM) was used to measure bite size, eating rate, deceleration rate and meal duration [10]. The SIPM consists of a concealed scale (Sartorius Cubis model), connected with a serial line to a PC, and secured beneath a purpose-built table under a hole, on top of which a place mat was secured to allow positioning of the plate. For this study, the software in the PC was programmed to record weight readings from the scale at 2 second intervals (precision 0.1 g), from which average bite size (the difference between each two consecutive weight records), eating rate (grams consumed per minute) and deceleration rate (grams consumed per squared minute) were calculated. The meal duration was divided into quartiles to explore changes in eating parameters over time [16]. Due to the high sensitivity of the SIPM equipment the data for bite size required cleaning. Records of < 1 g or > 23.4 g were excluded on the basis that they represented scale background noise or the result of the participant unknowingly applying weight or movement while sitting at the SIPM. These cut-off values were chosen after verifying the minimum and maximum weights of the test food that could realistically be loaded on the study fork.

2.3. Training session

The training session was designed to familiarize the participant with the individual eating booth and equipment where the SIPM was installed to minimize erroneous readings. Participants were asked to taste and rate the pleasantness of 4 foods, one of which was the test food (orange juice, tomato and cheese pasta bake, chili-con-carne, chocolate mousse), using electronic, 100 mm visual analogue scales (VAS). Immediately after the taste test participants were served 125 g of a chocolate mousse and asked to consume it in full while following explicit instructions to avoid leaning on the table while eating, position the spoon outside the bowl after finishing, and avoid tampering with the table and settings (i.e. placemat and screen). In line with the cover story, the volunteers were told that the eating and sitting requirements were necessary to standardize eating environment conditions across the participants. After the training session one participant disliking (i.e. a liking score < 40 mm) the chili-con-carne meal was excluded and replaced.

2.4. Experimental procedures

The participants attended 5 study visits at a selected lunchtime between 11:30 am and 2:30 pm, standardized for each individual and following a 3 h fast. The average starting time was 12:00 noon. The experimental conditions consisted of 5 different portion sizes of a main

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