A Detailed Analysis of Eating Behaviour

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ABSTRACT

The eating behaviour of human female volunteers is expressed as bursts of intake and intervening periods of rests and the cumulative intake curve can be modeled by a quadratic equation. The curve is negatively accelerated in some women and linear in others. Hence, women can be divided into decelerated and linear eaters. Here, we have studied the eating behaviour of decelerated and linear female eaters in further detail through analysis of video recordings of the maxillary-mandibular region and recordings of the plates from which the women ate and related these to weight loss data from the plates during meals. While the amount of food eaten is similar, decelerated eaters take fewer and larger mouthfuls per meal than linear eaters and the frequency of mouthful uptake decreases towards the end of the meal. Both types of eaters chew with stable rhythm throughout the meal, with the decelerated eaters chewing faster.

Author Keywords

Eating behaviour, eating styles, mouthful characteristics, chewing rate.

INTRODUCTION

Rat Drinking and Human Eating Styles

Early studies provided a detailed description of drinking in rats as a function of prior water deprivation [1,2]. The pattern of drinking is the result of successive "intake burst and rests". Since the rate of water intake is stable during the bursts, the cumulative intake of water simply equals the time the rat spends drinking, minus the duration of the "rests" [1]. As the length of the periods of rest increases by the end of an intake period, the cumulative intake curve is decelerated; hence rats are decelerated drinkers. Similar to drinking in rats, eating in human subjects consists of bursts and rests [3,4].

Figure 1. The Mandometer©, a personal computer connected with a scale recording the meal in real-time. Feedback to the user can be provided through the touch screen.

In the past we have developed an advanced mobile meal-recording device, the Mandometer©, with the ability to provide live feedback to the user during the meal (see Figure 1) [5]. By analyzing repeated evaluation meals, we have indentified two patterns of eating behaviour among healthy human female volunteers, based on real time weight data, collected from a scale placed under the plate [5]. By fitting such data to a quadratic equation, $y=kx^2 + lx$, the cumulative food intake emerges and subjects can be divided into two types of eater; those who start eating with a high rate (initial l-value) which is reduced towards the end of the meal ($k<0$) (decelerated eaters), and those who maintain a stable rate of eating throughout the meal ($k≈0$) (linear eaters) [5].

While decelerated eaters eat less food when the rate of eating is experimentally increased, linear eaters eat more food and while decelerated eaters maintain their intake at the normal level when eating rate is experimentally decreased, linear eaters eat less food [5]. In responding to these challenges, linear eaters thus conform to the eating pattern of patients diagnosed with Binge Eating Disorder (BED) and Anorexia Nervosa (AN), respectively [6]. We have demonstrated that practicing eating at the proper rate by use of real time visual feedback during the meal is a useful intervention in treating anorexic [7] and obese [8] patients and suggested that linear, but not decelerated eaters are at risk of developing such disorders [5,6].

In the present study, we present an innovative, semi-automatic way to analyze meals in depth, combining data from video and weighting scales. We apply our improved methods to further analyze the eating behaviour differences between decelerated and linear eaters. Hence, we analyzed the chewing pattern and mouthful management in the two types of eaters, keeping in mind possible future improvements to our clinical practice [7].

SUBJECTS AND METHODS

Subjects and Meal Sessions

Sixteen healthy female volunteers, with no history of eating disorders, participated in the study. They were served the same kind of food (chicken and vegetable pieces; 426kJ, 10.67g protein, 8.03g carbohydrate and 2.5g fat/100g) in three lunch sessions at 12.00h separated by about a week. The meals were served in a secluded room, without windows. During the meals, the external stimuli were minimized, as reading and listening to music was not allowed. These were "free" meals, with *ad libitum* food and time, without any kind of feedback. The effect of hunger variations was minimized by asking the participants to stick to a specific breakfast type and quantity during the test days.

After preliminary testing, subjects were divided into linear and decelerated eaters, who differed significantly in k coefficient (-0.14 and -0,48 respectively, $p< 0.02$, from an expected range of 0 to -0.65). Individuals in the two groups were similar in age (23.7 vs 23.3 years) and body mass index (BMI, 21.7 vs 21.4 kg/m2) respectively.

Data Collection

Data obtained from the weight loss of a plate during the meal [7] were combined with video recordings of mouth movements during the meal. A video camera (DigitalCam, Samsung, Korea) was directed at the plate and another one at the subject´s maxillary-mandibular region during the meal. The video recordings were manually time-stamped for the occurrence of food removal from the plate (spoonful), and for the occurrence of food entering the mouth (mouthful) and chewing action (any obvious lateral or vertical jaw movement). Spoonful and mouthful time stamping series were synchronized, using a custom made algorithm, eliminating discrepancies between the series, due to rare behaviors, e.g., double food uptake from the same spoonful and the final mouthful sequence of the meal was calculated.

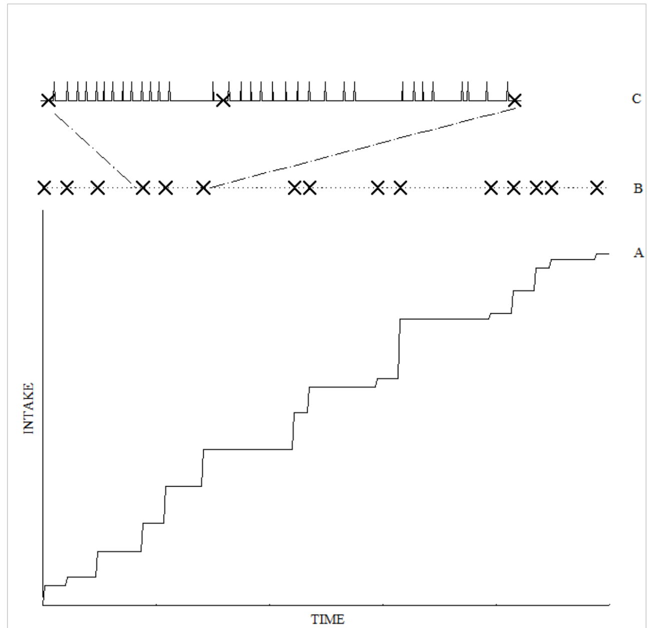

Figure 2. Schematic representation of meal characteristics. A. Cumulative intake over time based on weight reduction on scale, B. Mouthful sequence timestamped from video feedback, C. Detail of chewing occurrences as timestamped from video feedback.

Data Meta-Analysis

We developed a semi-automated procedure for processing a big number of meals in a short period of time.

Initially, the start and the end of the meal and the points of food additions to the plate were manually marked in relation to the weight loss data series.

Errors were filtered automatically by a heuristic algorithm, developed to correct possible errors using a "best-guess" procedure. The multi-step method involved: Characterizing a measurement as correct or mistaken, deciding about the error type (force on plate, utensil on plate or delayed weight registration) and finally correcting the measurement depending on the type of error. Numerous correction options were used: using a null-change value, subtracting the weight of the utensil or generating different unique values, based upon changes in the weight up to 16 sec before and/or after the measurement.

The weight loss data were then synchronized with mouthful sequences in relation to the starting point of the meal and fitted to a quadratic equation. Hence, the detailed eating style of each individual had been determined (see Figure 2).

This method allows calculation of the cumulative meal characteristics, i.e., food intake, meal duration and number of mouthfuls and chewing incidents. The precise load of each mouthful, as well as the chewing frequency during each inter-mouthful interval, were then calculated and averaged over meal thirds.

Results are reported as the mean values of the three meals, excluding measures of variability for simplicity. Group differences were evaluated by using t-tests and analyses of variance, followed by post hoc tests, as needed.

RESULTS

Food Intake, Meal Duration, Mouthfuls and Chewing.
Decelerated and linear eaters ate about the same amount of food (295 vs 289 g respectively), but decelerated eaters took their meal in a shorter period of time (8.4 min vs 11.3 min, $p < 0.04$) and had fewer mouthfuls (36.3 vs 48.9, $p < 0.02$). The number of chewing incidents didn't differ significantly between the groups (644 vs 740, $p > 0.3$).

Time Course of Mouthfuls and Chewing During the Meal.
While mouthfuls/min was similar among decelerated (4.9) and linear (4.8) eaters ($p > 0.9$) in the beginning of the meal, it decreased among decelerated eaters (3.9) during the last third of the meal and retained a stable rate among linear eaters (4.8) ($p > 0.3$). Additionally, decelerated eaters had significantly more food/mouthful than the linear eaters throughout the meal (group effect, $p < 0.05$). Still, both groups reduced their mouthful loads toward the end of the meal ($p < 0.0001$). Finally, decelerated eaters had a higher rate of chewing (chewing incidents/min) throughout the meal (group effect, $p < 0.02$), and both groups maintained their chewing rate over time (time effect, $p > 0.3$).

DISCUSSION

Eaters differ mainly in the rate at which food intake decelerates during the meal. It has been proposed that the lack of deceleration is a risk factor for the development of abnormal eating, which might lead to the development of long term eating disorders [5,6]. The method used here shows that this change reflects a reduction of the number of mouthfuls by the end of the meal. The load to mouthful ratio also decreased during the course of the meal, but this change was independent of the rate of deceleration of the meal. The rate of chewing remained constant during the meal, but was higher among decelerated than linear eaters, despite the fact that the load/mouthful decreased with time in both groups. The complete data analysis will include more detailed information about the course of chewing inside each individual mouthful, factoring in the duration of chewing pauses (evident in Figure 2C) between consecutive mouthfuls, together with the mouthful-specific load.

In our clinical practice, patients use decelerated cumulative intake curves, displayed on a computer monitor, as feedback when practicing eating (see Figure 1) [6,7]; the results presented here signify the existence of differences in the mouthful and chewing patterns of the two eater types, pointing to the need of additional research in that area together with the possible clinical significance of those characteristics.

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