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Short communication

Satiety. No way to slim

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ABSTRACT

This short overview considers a prospect that claims to boost satiety are used to prescribe or sell materials to dieters that do not slow their daily rate of energy intake, thereby worsening their problems with body weight and even perhaps increasing the prevalence of obesity. Implying that a drug or a food contributes to weight control by providing extra satiety is a mistake in two ways. First, the notion of a hormone analogue or a food constituent having a specifiable satiating power is scientifically incoherent. Secondly, a slimming satiety is a particular pattern of eating and drinking, in which substances have no fixed roles. Such a dietary custom has to be shown to produce a larger step decrease in weight with the medication or food product than without it. Suppression of food intake at a usual time for eating does not imply reduction in the eater's total intake of energy in a calendar period and hence lower weight while the material is still used within that eating pattern. It is the maintained pattern of behaviour that slims and prevents regain, not a satiety-augmenting substance. Regulators should not allow incomprehension of the basic science of energy balance to be exploited by advocacy of a food or medication for "satiety" believed by consumers to be a means of avoiding unhealthy fatness.

The issue: satiety as a slimming claim

Vigorous attempts are being made to obtain regulatory approval for products claiming to help reduction of weight by satiating appetite for food. There are increasing numbers of reviews, books and grants on satiety as an aid to slimming.[1] Yet, on scientific principle, such a general implication can never be true.

Definitions and measurements of satiety are beside the point. Two widely neglected facts are fundamental to the control of body weight.

The first is that average rates, not cumulative amounts, of energy intake and expenditure determine how much weight is lost or gained. This is the physics of fatness, an inescapable fact of the thermodynamics of energy balance.

The second fact is that any alteration in those rates of energy exchange produces a change in weight that comes to an asymptote while the altered rate of energy intake and/or expenditure persists. As the fat content of the body changes, lean mass changes in the same direction and hence also the rate of use of energy to keep those tissues working (Garrow, 1974).

It follows that any dietary way to slim must lower the rate of intake of energy for the weeks needed for a step reduction in body fat content. In addition, that way of losing weight must be maintained (or replaced by an equally effective means) in order to avoid regaining the initial fatness. Less food eaten or greater fullness rated over a test period does not in itself slow the daily rate of intake of energy. Even repeated observation of an acute suppression of intake does nothing to show a smaller total amount of energy intake over the period of the study. Feeling fuller after every meal is no guarantee of lower daily energy intake. It follows that no augmentation of satiety by a medically prescribed or commercially marketed material can be relied on by itself to reduce obesity or to prevent overweight for the years required to reduce the risks to health.

The science of support to effective weight-controlling food choices

Weight-controlling satiety therefore is not an effect of any sort of medication, food group or food product. Rather, satiety that slims is eating less often in ways that fatten by raising the average daily rate of intake of energy. That is, a 'slimming satiety' is an habitual pattern of eating and drinking that reduces weight when its frequency increases and is maintained throughout life at that new frequency (Blair, Booth, Lewis, & Wainwright, 1989; Booth,

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[1] For several reasons, research publications criticised here are not cited. They are readily identifiable by their authors and by informed readers (including the reviewers of this paper). It would be counterproductive to give such unhelpful papers further publicity. Much of the material appears in the 'grey' literature of presentations at conferences, chapters in books and other writing not subjected to expert peer review. Criticisms of evidence offered in support of a slimming claim have evoked threats of legal action, even though expert testimony in court against such claims has consistently turned cases against companies (Garrow, 2010).

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1980, 1996). Conversely, a 'fattening hunger' is an eating custom that increases weight when it occurs more often (Booth, 1996).

At least two clear examples of fattening hunger have been identified (Booth, Blair, Lewis, & Baek, 2004). One is a habit of selecting an option with a higher proportion of energy as fat, whether at a meal or between meals. The other is the frequent choice between meals of a small amount of food or a drink containing any source of energy, including starch, sugar or alcohol (Blair et al., 1989; Coakley, Rimm, Colditz, Kawachi, & Willett, 1998; Kayman, Bruvold, & Stern, 1990; Westenhoefer, von Falck, Stellfeldt, & Fintelmann, 2003). Nevertheless, high-fat choices might help to reduce snacking. A modicum of fat (and/or protein) within a meal may slow the rise of bodily hunger before and at the next meal at a conventional interval of 4–7 h (Booth, Chase, & Campbell, 1970). That rise in hunger might have resulted in the ingestion of energy between meals or an enlarged subsequent meal.

Generalising, an important slimming satiety could be a culturally recognised pattern of choices of foods and drinks at a meal that helps to prevent any intake of energy before the next meal, without increasing the energy content of either meal (Booth, 1988b). One might choose a quickly prepared and satisfying food for breakfast that contains a lot more protein than do cereal and toast. Also, slowly digested protein in lunches or evening meals might help to stop afternoon cake or eating just before bedtime. The same effect would be achieved if the hormonal signals generated by dietary protein towards the end of absorption of a meal were augmented by a long used food constituent or a safe new medication.

A widely suspected fattening hunger is habitual choice of more courses or larger portions at meals. The crucial issue though is not whether they are proportionately less filling. The only question is if the settled habit produces a insufficiently compensatory reduction in rate of energy intake measured as a step increase in weight.

Words and numbers versus realities

Research into these weight-controlling choices among foods and drinks has been gravely weakened by longstanding failures to measure the basic social, somatic and sensory mechanisms by which eating inhibits eating—the sating of appetite for food (Booth, 2008). These mistakes are rooted in systematic misuse of test-meal intakes and ratings of appetite (Booth, 2009). The result is misunderstandings about 'satiety' among experts in industry, medicine and academia and the funders and regulators they advise.

A prime example of the confusion created by such errors was the conclusion that only carbohydrate is strongly satiating, whereas fat and protein are weak satiators at best. The truth is that protein and indeed modest amounts of unemulsified fat are strongly satiating, and in ways that can be important for control of weight, while the role of carbohydrate-induced satiety must be minimal, for the following reasons.

Starch is often the most abundant energy-nutrient in a meal. Its digestion stimulates glucoreceptors, glucoregulatory hormones and glucose utilisation for the first hour or so after the meal (depending on the amount of carbohydrate). In contrast, amino acids from digestion of protein are sequestered in muscle, and the fat within solid foods is slowly digested and then circulates in chylomicrons, until the rate of absorption of glucose declines, leading to oxidation of alanine and glutamine from muscle and of fatty acids from the circulating fat.

Hence intake tests or appetite ratings within an hour or two of a meal can easily show reliable effects of its contents of carbohydrate but not of protein or fat (while all three are reflected in blood hormones and metabolites). However, such satiety (or blood chemistry) is irrelevant to slimming because food is seldom eaten so soon after a meal. Similarly, products that slow early digestion are unlikely to reduce daily rates of energy intake because such moderate delaying of assimilation does not affect the next meal.

Early research on the satiation of eating was built on recognition of this critically timed series of mechanisms activated by the consumption of food. Great damage has been done by using the term 'satiety' to label an imagined timeless property of constituents of foods, regardless of context of their eating in the culture, the body and interactions with others.

This unscientific notion also suffers from a severe statistical problem. The longer that a measure is made after an experimental manipulation, the more variable will be the mean value observed. Therefore reliable effects are harder to see with later intake tests or appetite ratings. In addition, tests near the next usual mealtime will be more constrained by habit and so additionally insensitive to effects of any prior manipulation. Nevertheless, large numerical effects (some also statistically reliable) have been seen at mealtime tests 3 or 4 h after intake of disguised variations in protein and/or fat (e.g., Booth et al., 1970; Cotton, Burley, Weststrate, & Blundell, 1994; Dibsdall, Wainwright, Read, & Booth, 1996; French, Wainwright, Booth, & Hamilton, 1992; Sepple & Read, 1990). These late effects on satiety, i.e. slowing of the rise in hunger, are the ones most relevant to slimming, both by helping to prevent snacking and also by moderating the size of the next main meal. It has indeed been shown that, at the same reduction of energy intake, sufficient protein in low-carbohydrate diets is crucial to the better compliance than seen with low-fat diets (Skov, Toubro, Ronn, Holm, & Astrup, 1999).

The concept of a biological marker for satiety also is fundamentally flawed by its neglect of the mechanisms of satiety. Merely correlating the areas under curves for blood glucose and ratings of fullness does not show how digestion products contribute to choices of when and what to eat, let alone any relation of those choices to obesity. The levels of gut hormones or of metabolites such as glucose or fatty acids in the blood cannot measure satiety because, even if a substance makes a contribution to normal inhibition of appetite, its physiological effects signalled to the brain and suppressing intake need to be tracked until they cease in order to measure the impact of the substance on rate of energy intake. There is not even a specifiable proportion of satiety at one moment under given conditions that is attributable to a particular mechanism. Arbitrarily timed 'satiety' tests provide no scientifically interpretable data.

In short, satiety can never be a property of a substance, whether in a food, in the blood, in a medication or in the brain. Hence it is impossible to design a valid physical test or marker for the satiety effect of a food or a drug. Indeed, satiety is irrelevant. The only way to identify a contribution of a substance to weight loss is to measure those mechanisms by which it influences customary patterns of uses of foods and beverages, so altering the rate of energy intake. Revival of this "psychobiological long haul" is vital to complement that "psychosocial short-cut" in its application to evidence-based public health policies, clinical treatments and the formulation and marketing of foods and drinks (Booth, 1988a, 1988b).

Failures to regulate implied slimming claims

The absence of such a scientifically sound basis for food policy has not stopped commerce and public health putting out product claims and educational messages that mislead about weight control. Indeed, regulators have even promoted such activities.

Slims "as part of a calorie-controlled diet"

British government regulations required any advertisement of a product that might be used in efforts to slim to include wording to