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ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Reducing Calorie Intake May Not Help You Lose Body Weight

Perspectives on Psychological Science
2017, Vol. 12(5) 703–714


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DOI: 10.1177/1745691617690878
www.psychologicalscience.org/PPS


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Abstract
As the widespread availability of highly calorific food has resulted in a high incidence of obesity, attempts to decrease body weight have concentrated on trying to reduce energy intake. It is suggested that this is not the best approach. Although consuming more calories than expended is part of the initial problem, it does not follow that reducing intake, unless consciously counting calories, is the best solution. Mechanisms smooth out the large day-to-day differences in energy consumption, decreasing the importance of the size of a meal. In the short term a reduction in energy intake is counteracted by mechanisms that reduce metabolic rate and increase calorie intake, ensuring the regaining of lost weight. For example, even a year after dieting, hormonal mechanisms that stimulate appetite are raised. Over a million calories are consumed a year yet weight changes to only a small extent; there must be mechanisms that balance energy intake and expenditure. As obesity reflects only a small malfunctioning of these mechanisms, there is a need to understand the control of energy balance and how to prevent the regaining of weight after it has been lost. By itself, decreasing calorie intake will have a limited short-term influence.

Keywords
body mass index, body weight, calorie deduction, obesity, weight gain

As it predisposes to many diseases, and decreases life expectancy, the increasing incidence of obesity is among the greatest problems facing the human race. By 2025, 18% of the world's male population and 21% of women will be obese (NCD Risk Factor Collaboration, 2016): In the United States 68% are already classified as overweight or obese (National Institute of Diabetes and Digestive and Kidney Diseases, 2010). Attempts to reduce obesity have focused on reducing calorie intake, but has too much time been spent looking the wrong way down the telescope? Is reducing calorie intake likely to fail as it ignores the mechanisms that the body uses to maintain its existing weight?

Psychological interventions have in common that they attempt to reduce calorie intake, for example trying to regulate appetite, increase satiety, or reduce portion size. It has been claimed that "portion size is a modifiable determinant of energy intake that should be addressed in connection with the prevention and treatment of obesity" (Rolls, Morris, & Roe, 2002). It has been said that "foods that target within-meal satiation and postmeal satiety provide a plausible approach to weight management" (Halford & Harrold, 2012). Alternatively effort has been directed to understanding appetite, although a systematic review failed to find an association between appetite and energy intake (G. M. Holt et al., 2017).

Trying to reduce calorie intake is also the fundamental principle that directs much of public health policy. The U.S. government dietary guidelines suggest that we should "Avoid oversized portions." In addition the number of calories is printed on food labels and lower calorie options are widely available in supermarkets. The U.K. policy on healthy eating suggests "putting calorie information on menus" and "helping people to eat fewer calories (for example by changing the portion size or the recipe of a product)."

However, obesity demands a more sophisticated approach than counting calories: It needs to be treated as an interdisciplinary topic. Those giving psychological advice need to be cognizant of aspects of both physiology and nutrition: Their recommendations must be compatible with bodily predispositions.

Biologists have tended to examine physiological mechanisms that influence energy balance. For example the lipostatic hypothesis suggests that a center in the hypothalamus monitors metabolites in the blood and,

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using feedback mechanisms, attempts to balance energy intake and expenditure (Kennedy, 1953). The approach gained a boost with the discovery of leptin, a hormone released from adipose tissue that reduces hunger. In contrast, psychologists typically expect the level of body fat to reflect aspects of the environment, food intake, or lifestyle. The present argument is that the interdisciplinary nature of obesity demands both approaches: There are interactions between physiology, the environment, and psychology. More specifically it is argued that having a reduction in calorie intake as the central plank of an anti-obesity strategy fails to acknowledge the existence of physiological mechanisms that predispose to its failure.

Psychologists interested in reducing obesity should consider altering their approach. Why is a reduction in calorie intake recommended when a lower energy intake leads to hormonal changes that stimulate appetite (Lean & Malkova, 2016), reduces metabolic rate (Dulloo & Jacquet, 1998), and stimulates the consumption of more calorific foods (Benton, 2005)? Although it may appear to be common sense to suggest that eating less will reduce the risk of putting on weight, this may not be the optimal approach.

As the approach taken by psychology is to reduce caloric intake, various questions are considered. How does the body respond to a small change in the caloric content of meals? How does obesity develop? What nutritional approach should be taken rather than simply concentrating on calorie intake? Finally, in the context of the resulting conclusions, how should psychologists study obesity?

How Does the Body Respond to a Small Change in the Calorie Content of Meals?

Advocating a reduction in the calorie intake reflects the implicit assumption that physiological mechanisms do not, to any great extent, balance energy intake and expenditure. However, from meal to meal and day to day, food intake is characterized by very large differences in the number of calories consumed. Before concluding that reducing the energy intake of meals will be influential, such changes need to be placed in the context of a wide range of social and psychological factors. In addition if meals vary greatly in size for a wide variety of reasons, and adaptations exist to smooth out these variations, changing the energy content of a meal is going to have a limited impact.

De Castro (1996) recorded food intake for a week or longer. He found that many psychological, social, cultural, and environmental factors affected the size of meals, influences that were powerful although short-lived. The size of a meal was described for the most part as "unregulated," "elastic," and varying "spontaneously within a relatively wide range." Social facilitation has a particularly powerful influence. He found that eating in the presence of one additional person increased the calorie intake by 44%, while eating with six others raised it by 74% (de Castro, 1996). In addition palatability, hunger, thirst, elation, and anxiety all influenced consumption. Dietary restraint has been found to be associated with consuming 301 fewer calories a day in females (1.26 MJ; 16%) and 279 kcal a day in males (1.17 MJ; 12%; de Castro & Elmore, 1988).

Faced with these wide variations in calorie intake, the important question is, how does the body respond? A simplistic suggestion is that a calorie is a calorie and therefore any raised intake of calories will inevitably result in an increase in body weight. However, even if this was the case, the impact of reducing the energy intake of some food items is going to be limited by the large influence of many social and psychological variables. The impact will be even less if, over time, there are mechanisms that smooth out the day-to-day variations in calorie consumption.

Reducing the size of meals

Implicit in the proposition that reducing the energy provided will help to control weight is the view that the energy consumed in one meal has a limited if any impact on subsequent consumption. However, over many years reviews have come to the same conclusion: Following a reduction in body weight, the lost energy is replaced by alterations in physiology and changes in the nature of the food consumed (Drenowatz, 2015; Poppitt & Prentice, 1996).

Energy compensation is more likely when you reduce rather than increase energy consumption. For example a study that lasted 14 days, carried out blind in a metabolic laboratory, found that subjects "completely compensated for the loss of calories." They increased the number of food items consumed that contained normal levels of calories. In contrast they "failed to compensate for an increase in caloric intake" (Foltin, Fischman, Emurian, & Rachlinski, 1988). Similarly Drenowatz (2015) acknowledged that humans are better equipped to replace lost weight than avoid weight gain, although the phenomenon is characterized by individual variability.

It is relevant that Poppitt and Prentice (1996) considered a time frame that excluded any preload study of less than 24-hr duration. This time scale is important as many psychological studies give a meal or a snack and then, after 120 or 150 min, measure food consumption. This time scale is not enough to allow full energy compensation although it has sometimes been wrongly quoted as evidence that compensation is of little importance. In fact

the time scale is critical as "energy balance in the lean is a long-term phenomenon, conditioned by large day-to-day fluctuations in energy intake" (Naismith & Rhodes, 1995).

Relevant experimental evidence is offered by studies where, unknown to the subjects, calories were removed from the diet. Any lost weight tends to be regained rapidly (Benton, 2005). It is essential, if you wish to demonstrate a response to changing the caloric content of food, that studies are carried out blind: Knowingly taking part in a study produces general changes in behavior (Benton & Young, 2016). It proved difficult to find studies that had covertly reduced energy consumption and monitored subsequent calorie intake as the majority of studies either had added calories or were not blind (Table 1).

Over a period up to 24 days, following covert energy reduction, all studies reported a degree of energy compensation that was variously 100% (Foltin et al., 1988; Lavin, French, & Read, 1997; Louis-Sylvestre, Tornier, Verger, Chabert, & Delorme, 1989; Reid & Hammersley, 1998), 70% to 80% (Foltin, Fischman, Moran, Rolls, & Kelly, 1990; Porikos, Hesser, & van Itallie, 1982), or 40% to 50% (Naismith & Rhodes, 1995; Porikos, Booth, & van Itallie, 1977), although it was only 16% in one instance (Foltin et al., 1992). The most common response in these nine studies was 100% energy compensation. That is, reducing the calorie content of particular foods resulted in no overall reduction in energy consumption. Yet at the other extreme there was a report of only 16% energy compensation. Understanding these differential responses may be the key to learning to benefit from a reduced calorie intake.

In addition energy compensation may be aided by changes in metabolic rate. For one day young women either fasted, consumed 1,200 kcal (5,040 KJ), or ate normally; then for 4 days they ate freely chosen meals (Levitsky & DeRosimo, 2010). Body weight decreased significantly after fasting or restricting the diet, although when allowed to eat normally the lost body weight was regained within 4 days. There had, however, been no increase in the amount of food eaten, and it appeared that reducing food intake had decreased the metabolic rate and thus ensured the recovery of body weight. This study suggested that the failure to maintain a reduced body weight does not necessarily reflect an increased appetite or a raised food intake; rather physiological mechanisms have important roles.

In the context of attempting to reduce body weight, this is the worst possible scenario. For example, when a larger portion supplies more calories, if it is part of a general and prolonged increase in energy intake it will tend to be stored as fat. The body does not try to reduce subsequent food intake to return to the preexisting body weight but rather anticipates starvation by storing energy. In contrast, if calorie intake is reduced, the body compensates by decreasing its metabolic rate or stimulating food intake.

The short-term regulation of energy consumption

Rather than assuming that decreasing calorie intake will inevitably influence body weight, a more sophisticated conception is that there are regulatory mechanisms that influence future food intake. When food intake was measured over days, de Castro (1996) found evidence of feedback mechanisms. These mechanisms were said to act "subtly but persistently," although they were not apparent for at least a day, and usually a longer period was required.

A study of military trainees during basic training found that on a day-to-day basis there was no relationship between energy intake and expenditure. However, after 2 days in some, and a longer period in others, adjustments were made (Edholm, Fletcher, Widdowson, & McCance, 1955). Again when cyclists taking part in the Tour de France were monitored, the association between energy expenditure and subsequent intake was closer after 3 to 5, rather than 1 to 2 days (Saris, 1997). Both of these studies examined those who were physically active; however, a similar finding has been reported in those displaying more normal levels of activity. When food intake was recorded for 2 weeks, if there were deviations from the average energy intake, after 3 to 4 days there were compensations in intake that were not observed after 1 or 2 days (Bray, Flatt, Volaufova, DeLany, & Champagne, 2008).

The findings are consistent. Food consumption is influenced by previous energy intake, often after as much as 4 days. Thus short-term studies, of the type that typifies much of the psychological work in this area, will be unable to examine the mechanisms that regulate food-intake. The existence of mechanisms that smooth out the day-to-day energy intake suggests that the minor changes in caloric intake associated with the modification of food items are unlikely to have a significant impact.

The Longer-Term Regulation of Energy Consumption

Dieting

What happens when, over a longer period, energy intake is reduced? Although a diet may produce a short-term gain, it is at a long-term cost.

Even one year after dieting, the levels of leptin, peptide YY, cholecystokinin, insulin, ghrelin, gastric inhibitory polypeptide, and pancreatic polypeptide have been

Table 1. Energy Compensation Following Covert Reductions in the Energy Content of the Diet

Study	Sample	Treatment	Energy Substituted	Duration	Food Available	Outcome
Porikos, Booth, and van Itallie (1977)	8 obese adults	Metabolic ward with sugar or aspartame foods	850 and 897 kcal during two periods	9 days sucrose and 6 days aspartame	Prescribed by stage of study	50% energy compensation
Porikos, Hesser, and van Itallie (1982)	6 normal-weight males	Metabolic ward with sugar or aspartame foods; Days 7–18 the caloric content reduced by 25%	900 kcal	24 days	Prescribed by stage of study	40% energy compensation after 4–6 days on low-calorie diet then 85% energy for rest low-calorie period
Foltin, Fischman, Emurian, and Rachlinski (1988)	6 normal-weight males	Metabolic ward with third of food low calorie on Days 6–11	500 kcal	14 days	Apart from periods of low-calorie foods a free choice	Days 6–11 100% energy compensation; Days 12–14 with regular foods available failed to compensate for increased caloric intake
Louis-Sylvestre, Tornier, Verger, Chabert, and Delorme (1989)	17 normal-weight males 15–17 years	Normal or low-energy snack (artificial sweeteners + fat) consumed for 5 days	200 kcal	6 days	Dinner provided 1 hour after snack on Days 1 and 6	Day 1 snack was not compensated at dinner; Day 6 there was precise energy compensation
Foltin, Fischman, Moran, Rolls, and Kelly (1990)	6 normal-weight males	Four lunches differing in fat and carbohydrate	Lunch offered 431 or 844 kcal	4 × 3 days	Apart from lunch freely chosen	76% energy compensation
Foltin et al. (1992)	6 normal-weight males	Metabolic ward with meals varying in fat and sugar/aspartame	Energy varied 700 to 1,700 kcal	4 × 3 days	Foods varied in energy content in 4 stages of study	16% energy compensation
Naismith and Rhodes (1995)	10 normal-weight males	Lunch sweetened with sucrose and then sweeteners	500 kcal	10 days	Freely chosen but foods varied in composition	42% energy compensation but varied from 0% to 90%
Lavin, French, and Read (1997)	14 female restrained eaters of normal weight	4 × 330 ml sweetened sugar/aspartame: half informed of nature of drink although did not influence energy intake	330 kcal	2 days	High-carbohydrate and high-fat snacks available with drink; Day 2 freely chosen	Over 2 days more energy consumed after aspartame drinks 111% compensation
Reid and Hammersley (1998)	14 normal-weight males and 13 females	Existing soft drinks replaced with those containing sucrose or aspartame	200–400 kcal	7 days	Freely chosen diet	Day 1 less carbohydrate consumed when aspartame consumed; by Day 2, there were no differences in intake, that is, energy compensation had taken place

found to differ from baseline values (Sumithran et al., 2011). A review concluded that "diet-induced weight loss results in long-term changes in appetite gut hormones, postulated to favour increased appetite and weight regain" (Lean & Malkova, 2016, p. 622). There are other physiological changes. When food intake was restricted, the resulting loss of body fat was associated with a decrease in the production of body heat and a reduction in metabolic rate (Dulloo & Jacquet, 1998), changes that will facilitate a return to the initial weight. More generally, the perceived reward of food increased following weight loss (Cameron, Goldfield, Cyr, & Doucet, 2008).

Given these responses to dieting, it is not surprising that it has been proposed that in the long term it does not work; any lost weight tends not to be maintained. In fact an examination of the long-term consequences of low-calorie diets found that between one third and two thirds of dieters regained more weight than they lost initially (Mann et al., 2007). Weight cycling, or more colloquially yo-yo dieting, refers to a cycle of weight loss followed by regaining the lost weight, followed by again dieting, and so on. The Summermatter Cycle describes how, initially during dieting, the energy expenditure of muscle reduces. Thus when more food becomes available, the more thrifty body favors the depositing of fat (Summermatter & Handschin, 2012). Such a mechanism illustrates that directing attention to the reduction of food intake, without realizing that it is the maintenance of weight loss that is important, is unlikely to be successful.

Weight fluctuation

Thus the body has as short-term goals the smoothing out of energy intake and maintaining the existing body weight. However, in the long term other mechanisms come into play that discourage large fluctuations in weight. Although over a period of months large amounts of energy are consumed, over time there are often relatively small variations in body weight.

The mechanisms are not perfect, but over long periods the ability of the body to balance energy intake and expenditure is staggering. It has been estimated that the average 45-year-old male in Western Europe consumes 1.24 million kcal (5,188 MJ) a year (Speakman & Westerterp, 2010). Similarly the United Nations Food and Agriculture Organization calculated that the average American consumes 3,790 calories (15.86 MJ) a day, a total of 1.38 million (5,774 MJ) a year. Based on food consumption data, the U.S. Department of Agriculture found that over a year the average American consumes nearly one ton of food.

However, although a large energy intake might be expected to be associated with putting on large amounts of weight, the figures do not add up. This level of energy intake needs to be placed in the context of the U.S. Department of Agriculture's Dietary Guidelines. The organization calculates that a sedentary adult male requires 2,200 calories (9.20 MJ) a day, that is 803,000 (3,360 MJ) a year. The comparable figure is 2,800 (11.72 MJ) a day in those who are physically active, adding up to an annual intake of 1.02 million calories (4,268 MJ). Without the intervention of compensatory mechanisms, this great excess of energy intake over expenditure would result in a massive annual increase of weight.

Although these ballpark figures cannot be expected to produce anything other than crude estimates, it is obvious that the weight of the average American is not increasing by anything in the range suggested by the difference between the actual and recommended levels of energy intake. Without compensatory mechanisms every year, this difference would result in an increase in weight approaching 100 pounds.

The body weight of those in the Framingham Study increased by a total of 10% over 20 years (Belanger, Cupples, & D'Agostino, 1988). Therefore, someone who was initially 150 pounds (68 kg) would 20 years later be 165 pounds (75 kg); that is, the person would have put on 0.75 pounds (0.33 kg) a year. When 15,624 Swedish women were monitored over 10 years, the annual weight gain was 0.75 pounds (0.33 kg; Norberg et al., 2011). In a Scottish population, over 9 years the average annual weight increase, in those initially aged 39 years, was 1.34 pounds (0.61 kg). Females aged initially 59 years, increased by 0.42 pounds (0.10 kg) a year and males by 0.20 pounds (0.13 kg; Ebrahimi-Mameghani, Scott, Der, Lean, & Burns, 2007). Similarly over 10 years a German study found an annual weight gain of 0.55 pounds (0.25 kg) in males and 0.53 pounds (0.24 kg) in females (Haftenberger et al., 2016).

In the context of the observed annual weight increase, it has been calculated that over a year 3,296 kcals (13.8 MJ) more energy would need to be consumed than had been expended (Speakman et al., 2011). These figures translate to a daily excess of energy intake over expenditure of only 9 kcal (38 kJ), a figure put in context by a teaspoon of sugar providing 16 kcal (67 kJ). Given the large number of calories often consumed, it is clear that factors other than calorie intake need to be considered.

There is, however, evidence that the analysis of weight change over long periods may be misleading. Weight may not increase gradually, but rather stay stable for long periods (Speakman et al., 2011), with weight gain occurring at times of excessive intake such as Thanksgiving or Christmas (Yanovski et al., 2000). This observation of periods of weight stability again suggests an ability to balance energy intake and expenditure. If for much of the time the body is able to generate energy balance, this would again argue against the expectation that reducing the caloric content of food will decrease body weight.

Average changes in weight, however, hide individual differences. The Scottish sample, for example, reported that the weight of 20% of the sample changed little over 9 years (Ebrahimi-Mameghani et al., 2007). Trying to understand why some manage to maintain their existing weight while others gain weight may be profitable.

A consistent picture has emerged. Even though excessive amounts of energy are consumed, over a year it is, on average, associated with only small increases in body weight. Clearly to understand the development of obesity we need to look beyond the number of calories that pass our lips. The impression gained is of finely tuned control mechanisms that monitor and respond to energy intake and expenditure. Examining these control mechanisms may well be more productive than reducing the caloric content of particular food items that are responsible for a small percentage of a million calories.

How Is Body Weight Determined?

A soundly based approach to dealing with body weight needs to reflect the mechanisms by which body weight is determined and maintained. Two main approaches have been suggested: There is a "set" or a "settling" point.

The set point theory suggests that the level of body fat is monitored and compared with a target value (Kennedy, 1953). As necessary, intake or expenditure is then modified to maintain the desired level of body fat. One problem with this approach is that it does not explain why the incidence of obesity has increased so markedly. A second issue is that it does not account for people with different lifestyles having a different risk of becoming obese.

In contrast, the settling point theory suggests that over time body weight is related to the pattern of food intake and physical activity into which people "settle" (Speakman et al., 2011; Wirtshafter & Davis, 1977). The biological mechanisms that control energy balance are programed by environmental factors, such that the point at which body weight is defended may change over time. The settled point is defended by metabolic and behavioral adaptations. Rosenbaum and Leibel (2010, p. S52) commented, "The multiplicity of systems regulating energy stores and opposing the maintenance of a reduced body weight illustrates that body energy stores in general and obesity in particular are actively defended." The model acknowledges that nutrition and physiology, as well as social, psychological, and economic considerations, all influence obesity. In addition, de Castro and Plunkett (2002) suggested that the defended point reflects both the internal and external milieu.

With the settling point approach there is a need to distinguish the initial development of obesity from subsequent attempts to reduce it. There can be no doubt that changes in the availability of food, and its increased caloric content, have played a major role in the obesity epidemic. It follows that public health advice has been to reduce food intake, although there has been limited success. Unfortunately, although the high level of calorie intake was a large part of the initial problem, it does not follow that its reduction will be a major part of the solution. When a reduction in calorie intake has decreased body weight, there are powerful physiological adaptations that favor regaining that weight (Greenway, 2015). When the initial attention associated with attempting to lose weight dissipates, body weight increases and returns to, or even exceeds, the starting level (Mann et al., 2007).

Obesity

The present argument that there are mechanisms that over time defend the existing body weight raises a question: If this is the case, why is there an obesity epidemic? There are various contributory factors.

First, obesity often reflects putting on one or two pounds (0.5 to 1 kg) a year for decades: That is, there is a very good, albeit not perfect, control of energy balance. Second, the nature of the entire diet is important. To prevent energy compensation, low-energy dense foods should be consumed (see below). However, many Western diets have a high energy density that rapidly compensates for any reduction in energy intake. Third, in many Western societies a major predictor of obesity is poverty (Drewnowski & Spector, 2004). Poverty is associated with a low expenditure on food, a low intake of fruits and vegetables, and a high intake of fat. The cheapest foods tend to have a high energy density.

Another part of the answer is that to control weight it must be possible to both lose weight and maintain that loss. It may be that it is not the amount consumed at a meal that is important but rather the lack of opportunity to prevent subsequent compensatory adjustments. Having eaten a large meal, is there an opportunity to subsequently reduce calorie intake? Often we do not eat because we are hungry but because it is meal time; we do not choose what to eat but rather eat what has been prepared by others; we consume a portion determined by those serving the meal, the food manufacturer, or the food outlet. As such, the opportunity to balance energy consumption and expenditure may be limited.

It is clear that obesity reflects many factors other than calorie intake and any coherent policy should address more than the caloric content of a meal.

If Not Calorie Reduction, What Approach Should We Take?

Although being aware of calorie intake is an approach often taken by those in control of their weight, the

present question is the extent to which reducing calorie intake can help more generally to decrease obesity. More specifically, is covertly decreasing calorie levels, for example by decreasing a portion size, going to be influential in those not consciously engaged in reducing intake?

The weight conscious are actively engaged with trying to not put on weight. As often these people are close to energy balance, counting calories is potentially a successful approach. There remain the two thirds of the U.S. population who are overweight if not already obese: In this circumstance, is reducing the calorie content of particular meals helpful?

Whereas those who are weight conscious are working at the margin of energy balance, and may even consume less energy than they expend, the obese tend to have an intake in excess of expenditure. In fact, as their intake is often greatly in excess of expenditure, over months a new and higher "settled point" is created. Why then should a small difference in calorie consumption greatly influence body weight? The settled point is defended, such that any decrease in energy intake will stimulate compensatory mechanisms. In those who are obese, calorie intake will reduce weight only if an energy deficit can be achieved.

Although both the obese and those who successfully control their weight are faced with powerful pressures to regain any lost calories, there are critical differences. Those maintaining a low weight often use cognitive strategies to prevent compensatory increases in calorie consumption. Those who put on weight may be unaware of psychological strategies or may choose not to use them. Unless the obese consciously engage with calorie control, requiring food manufacturers and food outlets to reduce portion size would be expected to be ineffective. If there is no conscious control of calorie intake, the body will simply replace the lost energy.

In addition, it is unlikely that minor changes in diet will reduce the incidence of obesity, as controlling body weight will often require a complete dietary makeover. It does, however, seem likely that concentrating on the nature of the food consumed, rather than simply reducing calories, offers advantages. An approach that considers macro-nutrients, energy density, and glycemic load may help to prevent energy compensation.

Diets that aid weight loss

There are reports that appetite, the control of body weight, and energy compensation are influenced by the macronutrient composition of meals (amount of fat, carbohydrate, and protein).

When in the short term the energy content of the diet is reduced, if some of the available foods are energy dense, that is they provide more calories per gram of food, then the lost energy tends to be replaced. In fact, after reducing calorie intake, only when the diet was uniformly of a low-energy density was energy compensation not observed (Poppitt & Prentice, 1996). A meta-analysis of observational studies found that a diet with a higher energy density was associated with a higher body mass index (Rouhani, Haghighatdoost, Surkan, & Azadbakht, 2016). As we tend to eat a similar volume of food, the same volume of low density foods provides fewer calories. Thus a low-energy diet has two advantages: It decreases energy intake but also helps to maintain any weight loss. Low-energy dense foods tend to have a high level of water and a low fat content; fruit and vegetables are good examples.

A satiety index has been developed that found eating foods that contained more protein, fiber, and water resulted in feeling fuller after a meal, whereas the fat content had the opposite impact (S. H. Holt, Miller, Petocz, & Farmakalidis, 1995). These findings were confirmed more recently when 100 foods were rated for their perceived ability to induce satiety. Foods with a lower energy density, lower fat, and higher protein accounted for most of the differences in the perceived ability to induce satiety (Buckland, Stubbs, & Finlayson, 2015).

A review of the effects of high protein diets concluded that there was "convincing evidence that a higher protein intake increases thermogenesis and satiety" and that "high protein meals lead to a reduced subsequent energy intake" (Halton & Hu, 2004, p. 373). Eating protein stimulates energy expenditure associated with its absorption, digestion, and metabolism (thermogenesis): This is estimated to be 23% of the energy consumed as protein, compared with 6% for carbohydrate and 1% for fat (Flatt, 1978).

After dieting, in a randomized trial for 6 months, either a high-protein or control diet was consumed. Satiety was higher and less weight was regained when high-protein meals had been consumed (Lejeune, Kovacs, & Westerterp-Plantenga, 2005). Similarly, a Cochrane review concluded that the overweight and obese lost more weight when on a low-glycemic-load diet; that is, they consumed a diet that produced smaller increases in the level of blood glucose. It was, however, noted that there was a need for longer term follow-up studies to establish a long-term benefit (Thomas, Elliott, & Baur, 2007).

In another study overweight adults lost 10% to 15% of their weight when they followed a low-carbohydrate, low-fat, or low-glycemic-index diet (Ebbeling et al., 2012). The fall in resting energy expenditure was, however, largest after the low-fat diet: an important observation as this would encourage energy compensation and the regaining of lost weight. In another study, subjects were monitored for 7 days while consuming covertly

manipulated diets (Stubbs, Harbon, Murgatroyd, & Prentice, 1995). After a delay of 3 to 4 days a greater intake of carbohydrate or protein, but not fat, was part of a negative feedback loop that reduced subsequent energy intake.

Hence, there is the potential to develop a diet based on the nature of the food items, rather than calorie content, that will help to maintain a lower weight. However, rather than concentrating specifically on the properties of individual foods, it should be remembered that it is the habitual pattern of eating that predisposes to obesity. Thus the opportunity exists for psychology to encourage the consumption of diets that are less likely to be associated with the gaining or regaining of weight. This will, however, involve considerations other than simply reducing calorie intake.

Discussion

In summary, a short-term priority of the body is to balance the extremes of energy intake that occur from meal to meal. As such, minor changes in caloric intake are unlikely to have a long-term impact. A second objective, following a loss of weight, is to ensure a return to the preexisting body weight. These mechanisms have implications for those recommending that we should try to reduce obesity by decreasing calorie intake: They suggest that the strategy, unless part of a wider intervention, will tend to fail.

In the longer term, the development of obesity reflects the assessment by the body that, over a period, excess energy had been consumed and thus a new higher "settled body weight" is established. Historically, it would be predicted that the marked societal changes that resulted in a positive energy balance would result in a higher "settled" body weight; for example, larger portion sizes, eating more often outside the home, decreasing physical activity, and the ready availability of cheap highly calorific foods. If history could be rewritten and these societal changes reversed, the chance that a younger individual will become obese would decline. Unfortunately, for those who are already obese, it does not follow that, by itself, reducing calorie intake will lead to a lower body weight. The existing body weight will be defended.

Although the physiological mechanisms that favor retaining body weight are powerful, this must not become a council of despair. Rather it should direct psychology to the examination of aspects of the environment and changes in behavior that can modify their impact.

A paradox

It may appear paradoxical to suggest that, when considering obesity, attention should not be directed primarily to the intake of calories. We are, however, fighting many aspects of modern Western society and bodily mechanisms that have developed over millions of years (Drenowatz, 2015; Greenway, 2015; Poppitt & Prentice, 1996; Rosenbaum & Leibel, 2010).

In theory the best strategy is to prevent obesity in the first place by ensuring that no more energy is consumed than is expended. In most cases, given the multitude of factors that influence the chances of achieving energy balance, such an objective will be achieved only after widespread societal changes. Thus in increasing sections of Western societies the body develops a "settled point" that reflects the levels of energy input and expenditure associated with obesity. How then should the problem of obesity be approached?

Historically, many of the attempts to develop public health policy can be summarized with the aphorism of the American journalist H. L. Mencken (1917): "For every complex question there is an answer that is clear, simple and wrong." It is unclear why, as all serious researchers acknowledge that the origins of obesity are wide-ranging and complex, public health initiatives have tended to emphasize a single or a few major influences. A good example was in the 1980s identifying fat as the villain, with the result that supermarkets are now filled with low-fat and "lite" options, yet obesity continued on the same upward trajectory. In a similar manner more recently attention has been paid by different groups to sugar, carbonated drinks, or portion size. Why is it believed that the origins of obesity are so simple that it is going to respond, even to a small extent, to isolated interventions?

The government of the United Kingdom commissioned a group to outline the variables that lead to obesity (Foresight, 2007). There resulted a list of 110 factors that were grouped into eight categories: food production, food consumption, physiology, physical activity, energy balance, the physical activity environment, social psychology, individual psychology. Each of these 110 factors was of considerable complexity and characterized by a maze of feedback loops. Fully acknowledging the complex origins of obesity emphasizes that it is fundamentally unlikely that the manipulation of a few isolated variables is going to make a significant difference. That is not to say that decreasing fat consumption or reducing portion size could not play a role, but only in the context of making changes to the entire diet. In fact dietary approaches can be expected to be successful only when part of a multifaceted, multidisciplinary inspired intervention.

Psychologists need to spend more time out of the laboratory as this location does not reflect most of the factors that determine weight gain. The most robust of laboratory phenomena may not survive interacting with

the wide range of factors that influence the tendency to put on weight. At the most laboratory studies are hypothesis generating and before an approach is recommended it needs to be tested under real-world conditions.

Maintaining a loss of weight

Although successfully controlling body weight is likely to involve a range of initiatives, many of which are unrelated to food, the nature of the diet inevitably plays a major role. The present analysis suggests that particular attention should be given to attempts to prevent the regaining of lost weight.

It is easy to propose that you should maintain a new lower weight but it is difficult to achieve. Losing weight, compared to maintaining weight loss, is relatively straightforward. There are hundreds of different diets, most of which will be to some extent successful, at least for a short period. However, of those who lose 10% of their weight, only 20% will maintain this loss for at least a year (Wing & Phelan, 2005). Thus in the short term it is possible to maintain weight loss, although very few will maintain that loss for 5 years. The aim should be to increase this percentage and to understand the factors that prevent the regaining of weight. What sort of behavior needs to be encouraged?

Behavioral changes

If reducing calorie intake is not to be the central driving principle, what is the alternative? Above, several approaches were outlined that could be used to develop a dietary style that will encourage the control of body weight. It would then need to be demonstrated experimentally that it worked. Finally, the problem for psychology will be to ensure its widespread implementation.

Strategic approaches

The major task is to develop strategies that encourage a consortium of behavioral changes that realize the benefits of an appropriate lifestyle. Dietary changes will be a part, but an appropriate lifestyle and helpful personality traits also need to be encouraged (Wing, Tate, Gorin, Raynor, & Fava, 2006). A first task will be to identify relevant aspects of behavior. Maintaining weight loss has been associated with high levels of physical activity, eating a low-calorie low-fat diet, eating breakfast regularly, self-monitoring weight, maintaining a consistent eating pattern across weekdays and weekends (Wing & Phelan, 2005).

For any strategy to work it needs to take account of the general environment. When studies of health-related behaviors were subject to meta-analysis various themes emerged (Kelly et al., 2016). Health-related behavior was limited by pressure of time due to family and work commitments, the financial cost, access to necessary resources, low socioeconomic status, lack of knowledge, and entrenched attitudes and behavior. However, it was helpful to focus on enjoyment, have social support, integrate new behavior into one's lifestyle, and have a clear message to follow. It is clear that any dietary intervention needs to be placed in a social and cultural context and the factors that facilitate or inhibit the process need to be acknowledged and reflected in a strategy.

Psychological engagement

Given the relentless physiological pressures to regain lost weight, the key factor in countering these tendencies is to consciously engage with the control of body weight. As such psychology has a particular role in identifying and facilitating advantageous cognitive styles and strategies. Maintaining a lower weight has been associated with increased dietary restraint, perceiving benefits as outweighing costs, having lower/stable levels of depression, and having a more positive body image. Similarly dichotomous thinking, that is, seeing things as extremes, comfort eating to regulate mood, and disinhibited eating were unhelpful (Ohsiek & Williams, 2011).

As an ability to monitor the intake of food is a characteristic of those who successfully maintain their weight over a long period, it has been suggested that people might be trained to self-regulate, perhaps using controlled exposure techniques (Johnson, Pratt, & Wardle, 2012). A review of the most successful means of self-regulation found that "higher autonomous motivation, self-efficacy, and self-regulation skills emerged as the best predictors" of a beneficial weight outcome. These were therefore suggested as possible targets when designing interventions (Teixeira et al., 2010). Another summary of the area concluded that interventions that incorporated self-monitoring (tracking one's own food-related behaviour), provided feedback on performance, prompted a review of behavioral goals, provided contingent rewards (rewarding diet success), and planned for social support were more successful (Prestwich et al., 2014). There was also evidence that attempts to manage stress improved the success of these approaches.

In a weight management program a high level of self-efficacy, the extent to which you believe you have the ability to accomplish a task, was associated with the loss of more weight (Bas & Donmez, 2009). An evaluation of attempts to increase self-efficacy concluded that "action planning," "providing instruction," and "reinforcing effort towards behavior" were associated with greater self-efficacy, suggesting approaches that could be taken (Williams & French, 2011).

Restrained eaters are individuals who watch their weight; they are continuously concerned about what they eat and try to limit intake. Typically their dietary restrictions may not be enough to lose weight, but they prevent weight gain. A review of prospective studies found that restrained eating did not predict future weight gain, although the weight of those who were dieting was more likely to increase (Lowe, Doshi, Katterman, & Feig, 2013). One explanation is that dieters and restrained eaters have a similar tendency toward weight gain, although restrained eating more effectively prevented it from happening. It is natural to suggest that the success of restrained eating will be enhanced by the judicial choice of foods that combine a low level of calories with the enhancement of satiation, the feeling that the meal is over, satiety, and how long it is before you again wish to eat.

Conclusion

In summary, any successful approach to controlling weight needs to take a wider and longer-term approach than studying the intake of calories. There is evidence of physiological mechanisms that monitor intake, although Western society often ensures that they are overwhelmed and obesity develops. However, although these control mechanisms are powerful, understanding how they function may be helpful. Rather than simply reducing calories, understanding the influence of the food consumed on satiety, satiation, and energy compensation may be advantageous.

It is, however, overly optimistic to expect a simple solution to such a complex and multifaceted problem. Given that the body actively attempts to maintain its existing body weight, we need to learn how to outflank such mechanisms. A first step will be to get beyond simply trying to reduce caloric intake.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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