

# The challenges of implementing behaviour changes that lead to sustained weight management

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## Summary

Weight loss is a difficult journey often characterised by repeated faltering attempts. There are numerous approaches to weight management but they all involve changes in self-management, eating or activity behaviour. Weight loss induces changes in physiological and emotional systems, which tend to pull people back to where they came from. At the present time, it is not clear how the rate, extent or type of weight loss impact on signalling systems that oppose weight loss. Dietary changes in behaviour appear to be more achievable for weight loss earlier in the weight loss journey, while physical activity becomes a critical adjunct to initial dietary changes for weight loss maintenance. A range of weight control behaviours characterises weight loss and weight loss maintenance. People successfully maintaining significant weight loss tend to control their appetite, do more physical activity and remain vigilant, to catch slips in behaviour that may lead to weight regain.

There may be differing clusters of behaviours, which characterise weight loss compared with weight loss maintenance, and there appear to be different clusters of behaviours that characterise weight loss maintainers. To navigate from the journey of weight loss to one of habitual weight loss maintenance requires long-term self-management. Environments and programmes that support, nurture and facilitate long-term behaviour change give people the capability, the opportunity and the motivation to navigate to a healthy weight.

**Keywords:** behaviour change, obesity, weight loss maintenance, weight loss, weight relapse

## Introduction

Most Western adults are now either overweight or obese, and this situation is storing up a crisis for global healthcare systems (Olshansky *et al.* 2005; Go-Science 2007). While prevention would have been better than cure, weight management is now necessary for many

adults in the general population. Western governments are aspiring to focus more on the proactive prevention of avoidable disease through lifestyle changes that reverse current obesity trends (Benjamin 2010; HM Government 2010). In principle, encouraging people to partake in healthier lifestyle choices would create the foundation of healthy habits that lead to greater well-being, quality of life and reduced healthcare expenditure for national healthcare budgets (Benjamin 2010; HM Government 2010). A key gap in achieving these goals is in encouraging individuals to engage the necessary behaviour change to affect weight loss. But, why is it so

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difficult to persuade people to lose weight and maintain their weight loss if it is in their best interests to do so?

There is a wealth of information on what healthy choices consumers should adopt to avoid weight gain and promote healthier weight outcomes. However, consumers are enmeshed in an 'obesogenic' environment that facilitates excess energy intake and low levels of energy expenditure (Swinburn & Egger 2002, 2004; Swinburn *et al.* 2011). It is becoming apparent that informed choice *per se* is insufficient to help consumers navigate towards a healthy weight (Cohen & Babey 2012). Equally, behaviour change strategies based on the concept of 'nudges' are not sufficiently comprehensive to overcome the complexity and gravitational force of environmental factors that facilitate weight gain and oppose weight loss (House of Lords 2011). In addition to these environmental factors, our own physiology appears (like that of many mammals) to be designed to 'bank' surplus energy to safeguard ourselves from seasonal uncertainty in the food supply (Stubbs & Tolkamp 2006; Prentice *et al.* 2008). These factors have implications for strategies we adopt to manage our weight in our modern environment, which constantly provides people with more readily available, palatable food energy than they require.

While in principle, the cost-effective way to influence weight control at the population level is probably through changes in eating, activity and weight management behaviours, in practice, it seems difficult for people to initiate and sustain the behaviours that would reduce the risk of excess weight and attendant disease. Why this is the case leads to a consideration of:

- (i) the challenges people face on their weight loss journey, which is by its nature a difficult journey;
- (ii) the behaviours associated with weight loss;
- (iii) the physiological responses to weight loss and why behavioural strategies may need to shift on moving from weight loss to weight loss maintenance;
- (iv) the behaviours associated with weight loss maintenance;
- (v) the relationship between physiology, emotion and behaviour, and how it affects weight relapse; and,
- (vi) how eating, activity and weight management behaviours can be implemented in the general population at the community level.

### Challenges posed by the weight loss journey

As documented by the *Foresight Commission* obesity maps, (Go-Science 2007), the first challenge people face in losing weight is posed by the environment we live in (Go-Science 2007; Swinburn *et al.* 2011). Little effort is

required to gain weight. For example, US adults (*i.e.* over 18 years) appear to drift upwards in weight at an average rate of 0.2–2.0 kg/year (Kant *et al.* 1995a, 1995b; Truong & Sturm 2005). Overweight seems to result from 'normal' feeding responses when exposed to a Western diet under modern sedentary conditions (Stubbs & Tolkamp 2006). There is little evidence that regulatory signals protect us from slow, incremental weight gain over time. Conversely, for most people, considerable effort is required to lose weight and sustain the loss. Weight loss is a difficult journey, which is often punctuated by repeated attempts and lapses (Brownell *et al.* 1986; Brownell & Rodin 1994). We use the word journey to convey the meaning that weight loss is a 'long and often difficult process of personal change and development' ([www.oxforddictionaries.com/definition/english/journey](http://www.oxforddictionaries.com/definition/english/journey)).

It is now well recognised that weight loss trajectories slow as time progresses (IOM 1995; Glenny *et al.* 1997; Franz *et al.* 2007). The exact mechanisms that oppose further weight loss and often promote weight regain are multiple, complex, individually subtle and difficult to quantify specifically, although they include changes in energy expenditure (Leibel *et al.* 1995; Weinsier *et al.* 2000; Heilbronn *et al.* 2006; Martin *et al.* 2007; Bosy-Westphal *et al.* 2009; Hall 2012; Schwartz *et al.* 2012) and physiological signals (Weigle *et al.* 2003; Kotidis *et al.* 2006; Maestu *et al.* 2008; Pardina *et al.* 2009; Crujeiras *et al.* 2010) that may be concerned with appetite and energy intake (Doucet & Cameron 2007; Sumithran *et al.* 2011). This means that a path of behaviour change to promote weight loss is trodden across shifting physiological sands, which may influence the actual behaviours people are trying to change. The fact that weight loss trajectories are curvilinear is reproducible across a range of treatments. In general, for a variety of treatments, the average rate of weight loss is greatest in the first six months and decelerates towards a plateau thereafter (Glenny *et al.* 1997; Franz *et al.* 2007). Given that weight loss curves generally decelerate, weight management programmes should aim to help people achieve weight loss trajectories that plateau and are maintained at a healthy weight. Thus, weight loss programmes should also include components that promote weight loss maintenance in the longer term (Glenny *et al.* 1997; WHO 2000; NAO 2001; NICE 2006; Franz *et al.* 2007). For many, obesity can be viewed as a chronic relapsing condition, for which at present there is no simple cure. Long-term chronic conditions require management and recognition of relapse signatures (*i.e.* early warning signs in patterns of behaviour) at the level of the individual (Brownell *et al.* 1986; Brownell &

Rodin 1994; Stubbs *et al.* 2012b). This does not mean that all weight loss attempts are doomed to failure. Indeed, it is estimated from prospective studies that ~20% of the general population are successful in losing and maintaining a weight loss of ~10% over 3–5 years (Wing & Phelan 2005). It does, however, suggest that the behaviours associated with initial weight loss *per se* may not necessarily lead to long-term successful weight loss maintenance. Behaviour changes initiated to lose weight may need to adapt as weight loss proceeds, so that weight stabilises at a new lower level.

### Behaviours associated with weight loss

There are multiple behavioural pathways to and from obesity (Go-Science 2007). While most people lose weight in generically similar ways (*i.e.* diet and physical activity), specific dietary and physical activity behaviour changes differ widely between individuals (Stubbs *et al.* 2011a). There are a variety of different approaches to engage people in weight loss, including various dietary programmes, physical activity programmes, different behavioural therapies, social support, drugs and several forms of bariatric surgery (IOM 1995; Glenny *et al.* 1997). Many weight management programmes involve combinations of these approaches and they all encourage or induce fundamental changes in behaviour at the level of self-management, diet and/or physical activity. There is currently a very limited selection of drugs for the treatment of obesity [Orlistat and Qsymia (phentermine and topiramate extended-release), which has recently received Food and Drug Administration approval in the United States] and surgery is only available to a small section of the population (NICE 2006). For the majority of the population, weight management solutions necessarily take the form of behaviour modification interventions. The actual nature of such interventions themselves has changed over the years. Interventions have increased in duration, intensity, the degree of social support or engagement and in complexity (*i.e.* the number of behaviour change techniques involved) (Stubbs *et al.* 2011a). Changes in the length, intensity and degree of social support have all had beneficial effects on weight outcomes (Stubbs *et al.* 2011a). It is not clear, however, whether there is an optimum level of intervention complexity with which the general population can engage (Dombrowski *et al.* 2010). Some interventions may be too simple (*i.e.* insufficiently comprehensive) while others may be too complicated and overload individuals with too many behaviour change techniques.

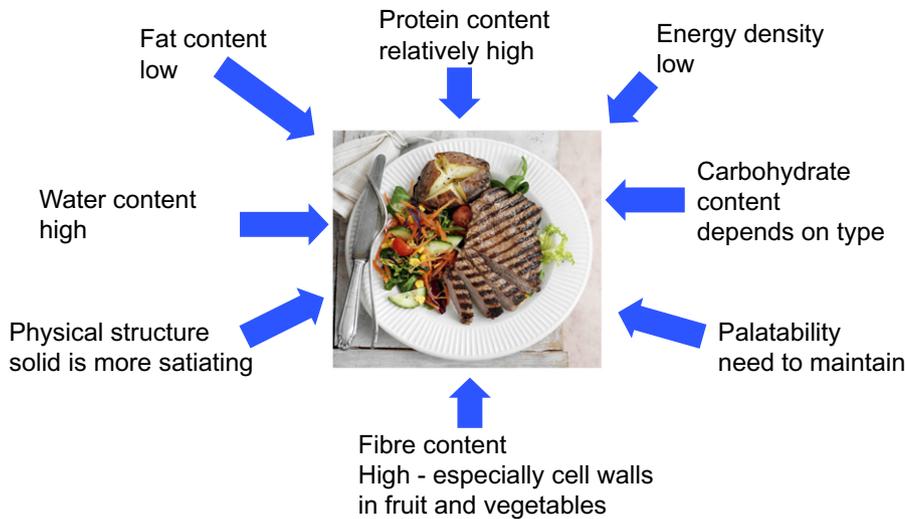
In humans, energy balance is primarily altered by changes in eating and activity behaviours. The capacity

to increase energy expenditure through changes in activity behaviours is more limited in overweight people due to a lower physiological fitness (Broeder *et al.* 1992) and a greater psychological problem of self-awareness associated with participation in physical activity. At the beginning of a weight loss journey, it appears that the most effective way to alter energy balance is by altering energy intake through changes in dietary behaviours. This begs the question, which dietary habits are most efficacious for weight loss?

### Managing appetite and energy intake

Satiety is important for weight control (Wing *et al.* 2008; de Graaf 2011). When 292 long-term weight loss maintainers were asked why they previously broke a diet, ‘being hungry’ and ‘restricted’ foods were in the top three out of nine reasons. Primary factors important to participants in reaching their target weight were being able to not go hungry by filling up on low-energy density food they could eat *ad libitum*, after a flexible diet, peer-group support and tools to cope with small lapses (Stubbs *et al.* 2012a). So it would appear that consumers want dietary solutions that help avoid hunger and the sense of deprivation associated with more restricted diets. Foods that contain more structural components such as protein and fibres will require more time to ingest and digest than foods that are easily and rapidly chewed, digested and absorbed. Thus, prioritising an increased intake of foods generally agreed to be healthy (*e.g.* fruits, vegetables, lean meat, staples) has the benefit of increasing meal size to energy intake ratios, increasing time to consume and digest foods, potentially displacing less healthful foods from the diet and preventing passive overconsumption of energy-dense foods rich in fats and readily assimilated carbohydrates, which are a higher risk for overconsumption (Stubbs *et al.* 2010).

There is a consensus that low-fat, low-energy dense diets are effective in the long term for promoting healthier dietary behaviours and for weight management (Kant *et al.* 1995a; Prentice & Poppitt 1996; Drewnowski 1998; Astrup *et al.* 2000; Stubbs *et al.* 2000; Blundell & Stubbs 2004; Drewnowski 2007; Ello-Martin *et al.* 2007; DH 2008). Dietary energy density is of major importance because it can override some of the effects of dietary macronutrient composition (Stubbs *et al.* 2000). Bearing this caveat in mind, single dietary approaches to weight management, such as fat reduction, low carbohydrate diets, low glycaemic index diets or higher protein diets are limited in their effects on weight outcomes. Because of this there has



**Figure 1** The combination of dietary behaviours that may most effectively manage satiety, limit energy intake and promote steady weight loss over the longer term (Stubbs *et al.* 2010).

been a growing interest in combining individual dietary approaches into a package of dietary behaviours that help promote satiety and limit energy intake. These include consuming a diet of low-fat content (Yu-Poth *et al.* 1999; Astrup *et al.* 2000) with a tolerably low energy density of  $\sim 1.1\text{--}1.3$  kcal/g (Rolls 2009; Stubbs *et al.* 2010) and a high water content (Stubbs *et al.* 2000; Rolls 2009). It is helpful for weight loss to avoid, where possible, caloric and alcoholic beverages (Mattes 1996; DiMeglio & Mattes 2000; Mattes 2006; McKiernan *et al.* 2009). The fibre content of weight-reducing diets should be tolerably high (not much more than 20–30 g day) (Howarth *et al.* 2001; Slavin 2005; Slavin & Green 2007). Protein is the most satiating macronutrient and some (Larsen *et al.* 2010; Johnstone 2012; Westerterp-Plantenga *et al.* 2012), but not all (Sacks *et al.* 2009; Aldrich *et al.* 2011), studies suggest that a diet with a higher protein content (probably not exceeding 20–25% of an energy-reduced diet) is beneficial for weight loss. Higher protein diets promote satiety during weight loss (Leidy *et al.* 2011; Westerterp-Plantenga *et al.* 2012), but as for other dietary monotherapies, the effects are relatively modest. The carbohydrate content depends very much on type (Stubbs *et al.* 2001). Sweet, short chain carbohydrates can promote higher levels of energy intake, especially when combined with fat, *e.g.* (Drewnowski 2007). More complex, slow release carbohydrates may be more beneficial for satiety and prevention of overconsumption (Blundell & Stubbs 1998). The orosensory properties of foods need to be maintained to encourage people to select those foods, so that they become a practical option for the development of healthy eating habits (Drewnowski 1998; Stubbs & Whybrow 2004). This package of changes in dietary

behaviours that are likely to assist with weight loss is depicted in Figure 1.

### Physical activity behaviours

Evidence that physical activity interventions increase weight loss in the short term is remarkably disappointing. Physical activity interventions for weight loss involving 60–180 minutes per week, ranging from 4 to 16 months, have shown only a modest effect of increasing physical activity on weight outcomes (*i.e.* physical activity groups lost 1–3 kg more than controls) (Catenacci & Wyatt 2007). Studies that have added physical activity interventions to dietary interventions do not show a proportionately large benefit in relation to the activity intervention, in the short to medium term (Wing 1999). It appears that physical activity is more efficacious for weight loss in interventions when participants actually engage with the activity intervention (Wu *et al.* 2009). Indeed, it has been shown that the effectiveness of physical activity interventions is primarily a function of engagement (Jakicic *et al.* 2008). The American College of Sports Medicine suggests that physical activity will produce clinically significant weight loss at higher doses. Moderate/vigorous activities above 225 minutes per week are associated with weight losses of 5–7.8 kg (Donnelly *et al.* 2009). However, interventions at this level are subject to lack of compliance. This is perhaps not surprising when we consider the intervention population. The majority of people engaging in weight management programmes are habitually sedentary and unfit. Their capacity to significantly increase energy expenditure through activity is limited. While physical activity *per se* has a limited impact on initial

**Table 1** Self-management behaviours associated with weight loss

Behavioural changes	Key points
Self-monitoring	Self-monitoring of behaviour (e.g. weight, diet and activity) is strongly associated with weight loss.
Planning and flexibility	Planning (when, where, how) and flexibility correlate with weight loss. Rule-bound rigidity and impulsiveness are associated with poorer weight outcomes.
Coping strategies	A more autonomous coping strategy is associated with weight loss.
Locus of control	A more internal locus of control (e.g. belief that outcomes are under one's own control) is associated with weight loss.
Self-efficacy	Belief in one's ability to change behaviour is associated with weight loss in some, but not all, studies.
Self-motivation	Self-motivation predicts successful dietary and exercise behaviour change.
Attitudes	More autonomous attitudes appear to be related to successful behaviour change.
Body image	Concerns with body image yield mixed results. In some cases, they are related to motivation and success; in others to eating disorders. Some evidence suggests increases in physical self-worth and body attractiveness and body shape concerns are associated with weight loss.
Self-esteem	The relationship between weight and self-esteem is bidirectional – they can affect each other. Weight loss improves self-esteem but low self-esteem is unlikely to improve weight loss.
Outcome expectancies	Outcome expectancies often exceed actual weight outcomes. However, there is little hard evidence to support modest weight loss goals.
Goal setting	Goal setting is related to weight loss. Revising goals as weight loss proceeds can improve motivation and avoid undermining expectancies.
Dietary restraint	Flexible dietary restraint is associated with weight loss. Rigid dietary restraint is associated with relapse. Disinhibition of restraint is associated with relapse.
Binge eating	Intuitively binge eating would be expected to correlate with poor weight loss. Evidence is mixed. Binge eating disorder is a complex condition and is not always strongly associated with degree of overweight.
Emotional eating	Higher levels of emotional eating are associated with poorer weight loss and greater relapse.
External eating	Greater responsiveness to external food cues is associated with poorer weight loss.
Weight cycling	Weight cycling is generally associated with poor weight loss but this is almost axiomatic.
Slowing rate of eating	Slower rate of eating has been associated with weight loss. This appears related to the type and composition of foods consumed.
Perceived hunger	High levels of perceived hunger are associated with poorer weight outcomes.

Derived from information contained in Jeffery *et al.* (1984); Foreyt & Goodrick (1991, 1995); Westenhoefer (1991); Prochaska *et al.* (1992); Wadden & Letizia (1992); Allison & Engel (1995); IOM (1995); Wilson (1995); Foster *et al.* (1997); Klem *et al.* (1997); McGuire *et al.* (1998); Fontaine *et al.* (1999, 2004); Kolotkin *et al.* (2001); Heshka *et al.* (2003); Teixeira *et al.* (2004, 2005, 2010); Westenhoefer *et al.* (2004); Elfhag & Rössner (2005); Wing & Phelan (2005); Blaine *et al.* (2007); Pan *et al.* (2011); Stubbs *et al.* (2011a).

weight loss, it is extremely important for weight loss maintenance. One hallmark of success for weight loss maintainers is their high level of physical activity compared with how active they were before they lost weight, or to the general population (see below) (Wing & Phelan 2005; Ogden *et al.* 2012).

### Self-management behaviours associated with weight loss

When considering behaviours associated with weight loss on aggregate, surprisingly there is insufficient evidence to put them in rank order. However, behavioural factors consistently associated with successful weight loss include self-monitoring, eating self-efficacy, plan-

ning (*i.e.* when, where, how), motivation, goal setting, flexible restraint, social support and starting to become physically active. Several salient aspects of behavioural self-management are associated with weight loss (Foreyt & Goodrick 1991; IOM 1995; Elfhag & Rössner 2005; Teixeira *et al.* 2005; Teixeira *et al.* 2010; Stubbs *et al.* 2011a). These are summarised in Table 1.

### Treatment and process factors

Many of the changes that occur during the process of weight loss become the basis for habitual weight maintenance behaviours. Some treatment correlates of weight loss thus become maintenance strategies but these processes are variable within and between people

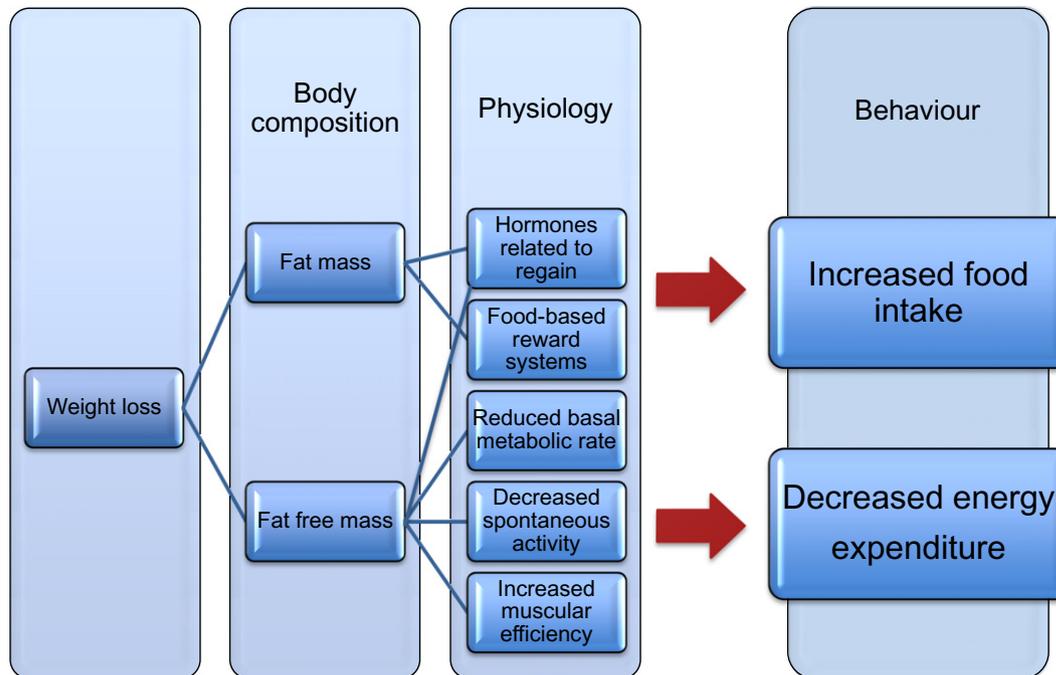
(Stubbs *et al.* 2011a). Positive process factors include programme attendance and early weight loss. Positive treatment factors included length of treatment, social support, incorporation of behaviour modification techniques (especially self-monitoring and goal setting) and increased engagement in physical activity (IOM 1995). The most consistent negative predictors of weight loss are the opposite of positive predictors, with the addition of repeated attempts at weight loss and the experience of perceived stress (IOM 1995; Wilson 1995; Elfhag & Rössner 2005; Teixeira *et al.* 2005). These two factors may well be related. A key component of relapse is the inability to develop coping strategies that manage various forms of stress (including weight loss) in everyday life (Brownell *et al.* 1986; Friedman & Brownell 1995; Elfhag & Rössner 2005; Teixeira *et al.* 2005).

Some studies have attempted to identify behaviour change ingredients of complex interventions associated with weight loss, using a taxonomy of behaviour change techniques (Michie *et al.* 2009; Dombrowski *et al.* 2010). The Meta-analyses of associations between behaviour change techniques and health outcomes in different interventions show considerable heterogeneity between studies. Michie *et al.* conducted meta-regression on 122 evaluations of diet and activity (varying in duration from one session to 2.5 years). Using pooled data, behaviour change, interventions showed better outcomes than controls but the effect size was modest (0.31). Most behaviour change techniques examined explained very little of between-study heterogeneity, with self-monitoring of behaviour explaining the most at 13%. Of 26 possible behaviour change techniques, the average number was six per intervention (Michie *et al.* 2009). The study by Michie *et al.* assessed 'valid outcomes of physical activity and healthy eating' (Michie *et al.* 2009), which may not be directly related to weight outcomes. Dombrowski *et al.* conducted a meta-analysis of 44 studies, averaging 6.2 months in duration (Dombrowski *et al.* 2010). They examined the relationship between behaviour change techniques used and weight outcomes. For dietary interventions, they found that provision of instruction to participants, self-monitoring and relapse prevention were linked to better weight outcomes, explaining 26%, 40% and 24% of between-study heterogeneity, respectively. Prompting practice was related to physical activity interventions and explained 48% of between-study heterogeneity in weight outcomes. Weight outcomes are more likely to be precise and accurate than measures of eating and activity behaviour, which are notoriously hard to measure, without the inclusion of energy balance methodology.

Thus, a variety of behavioural factors are associated with weight loss. The curvilinear trajectory of weight loss that is characteristic of most weight management interventions suggests that there is a transition from weight loss to either weight loss maintenance or weight relapse.

### **The transition from weight loss to weight loss maintenance**

It is interesting to consider why weight loss curves decelerate and how behaviour might change in relation to this weight loss trajectory, on going from weight loss to weight loss maintenance. It is beyond the scope of this text to detail the physiological responses to energy deficits, but a summary overview is useful. Weight loss changes body composition. The majority of weight loss is in the form of reduced fat mass, but fat-free mass also decreases with weight loss, depending on initial body composition and the rate of weight loss (Hall 2007, 2010). The changes in body composition influence physiological signalling systems, which attempt to prevent further weight loss and even promote weight regain. There is now considerable evidence that weight loss-induced decreases in fat mass influence hormone cascades that can act as cues promoting behaviours which lead to subsequent weight regain (Weigle *et al.* 2003; Kotidis *et al.* 2006; Maestu *et al.* 2008; Pardina *et al.* 2009; Crujeiras *et al.* 2010). Thus, physiological changes related to decreases in fat mass should favour an increase in appetite and food intake (Wing *et al.* 2008; Sumithran *et al.* 2011; Kissileff *et al.* 2012). Decreases in weight and fat-free mass will reduce basal metabolic rate and total energy expenditure (Leibel & Hirsch 1984; Leibel *et al.* 1995; Weinsier *et al.* 2000; Martin *et al.* 2007; Hall 2010, 2012). Weight loss is associated with a decrease in spontaneous physical activity both during semi-starvation (Keys *et al.* 1950) and therapeutic calorie restriction (Redman *et al.* 2009). There is some evidence that decreases in fat-free mass lead to increased muscular efficiency (Rosenbaum *et al.* 2003; Goldsmith *et al.* 2010). It is also likely that the decreases in fat-free mass also trigger hormone cascades, which influence appetite and energy intake, although these are currently less well mapped at the present time (Blundell *et al.* 2012a, 2012b). These changes in fat-free mass will collectively decrease energy expenditure (Leibel *et al.* 1995; Stubbs *et al.* 2003; Redman *et al.* 2009; Hall 2010, 2012). Thus, weight loss influences physiology and behaviour in a way that attempts to restore body weight to pre-weight loss levels, unless additional behavioural strategies are invoked. This is the challenge for weight loss maintenance. Generating a negative energy balance through diet

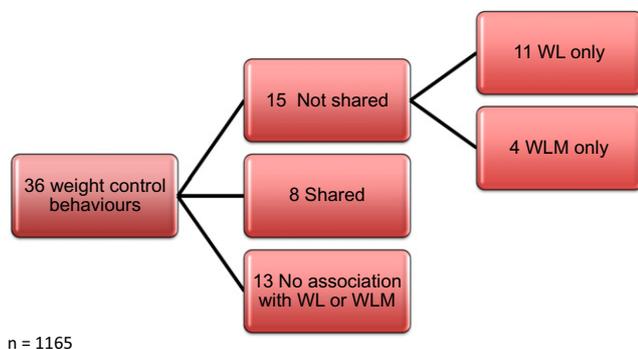


**Figure 2** Schematic diagram of how weight loss influences physiology and subsequent behaviour in response to energy deficits.

and physical activity at a constant rate would invoke the laws of diminishing returns due to passive changes in physiology (which decrease energy requirements), decreases in activity behaviours and increases in hormonal signalling systems believed to increase appetite. As weight is progressively lost, evidence suggests that physiological signalling systems actively oppose further weight loss (Leibel *et al.* 1995; Stubbs *et al.* 2003; Redman *et al.* 2009; Hall 2010, 2012; Sumithran *et al.* 2011; Kissileff *et al.* 2012). Substantial weight loss induces physiological changes that pull you back to where you came from. These changes characterise the transition from weight loss to weight loss maintenance and explain why it may be important to shift behavioural strategies between those used for losing weight and those used for successfully maintaining the weight loss in the longer term (Fig. 2).

Some studies are now beginning to show that the behaviours associated with weight loss may not be exactly the same range of behaviours that are associated with weight loss maintenance. In a recent study conducted at Penn State University in 1165 people, 36 weight control behaviours were examined. These were split into dietary, physical activity, cognitive and tracking (*i.e.* self-monitoring) behaviours. Participants were asked to what extent they engaged in these behaviours in relation to their weight change in the preceding 12 months (Sciamanna *et al.* 2011). The sample was split

into those who were weight loss maintainers and those who had lost weight in the recent past. Thirteen of these weight loss behaviours showed no association with weight loss or weight loss maintenance. Eight weight control behaviours were shared between weight loss and weight loss maintenance in the study population. For example, those who reported limiting more often the amount of carbohydrates were more likely to report successful initial weight loss and successful weight-loss maintenance, compared with those using these practices less often. However, 15 weight control behaviours were not shared between weight loss and weight loss maintenance. For example, those who reported engaging in different kinds of physical activities more frequently or planning what was eaten ahead of time were more likely to report successful initial weight loss but not weight-loss maintenance. Of these unshared behaviours, 11 were specific to weight loss only and four were specific to weight loss maintenance only (Sciamanna *et al.* 2011). For example, those who reported a consistent physical activity routine more often and those who reported a more frequent intake of low-fat sources of protein, were more likely to report successful weight-loss maintenance but were not more likely to report successful initial weight loss. This initial study suggested that weight loss and maintenance may involve two clusters of behaviour, which are to some extent shared and to some extent different (Fig. 3).



**Figure 3** Clusters of behaviours associated with weight loss and weight loss maintenance in a national survey of 1165 people. This study suggested that weight loss and maintenance may involve two clusters of behaviour, which are to some extent shared and to some extent different (Sciamanna *et al.* 2011).

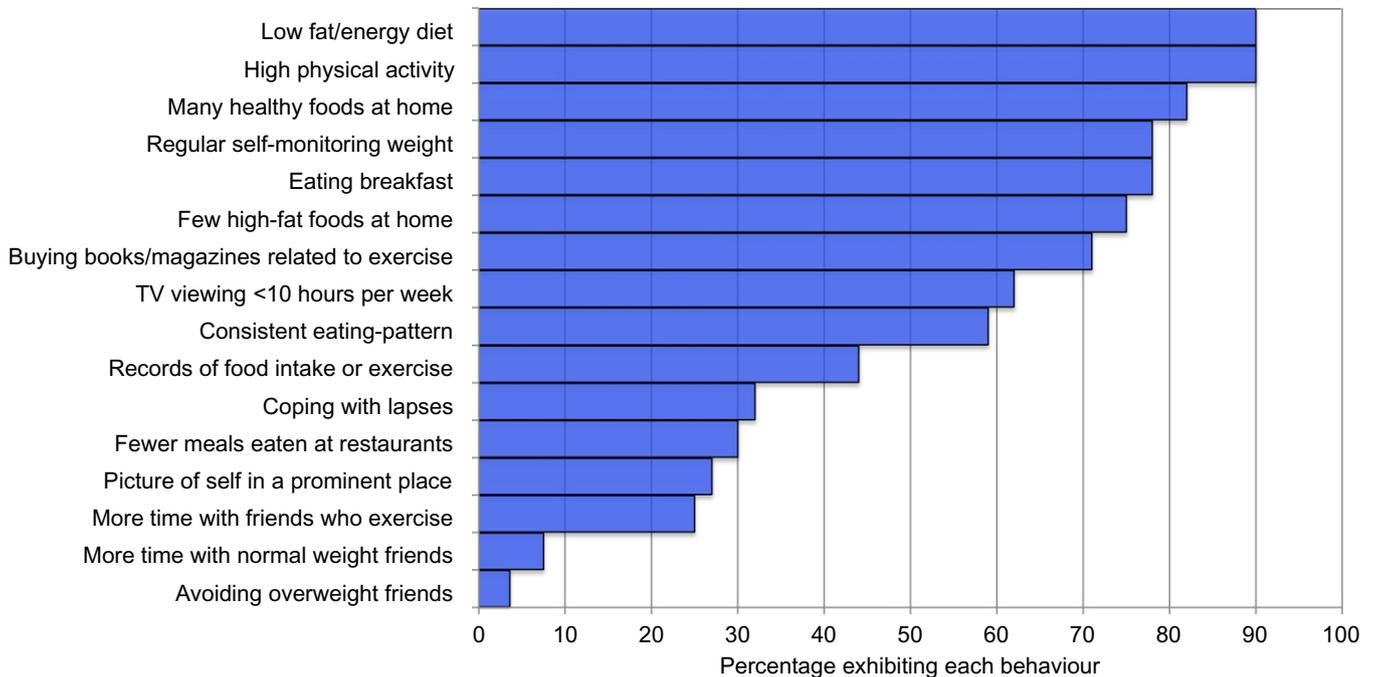
Another interesting study conducted by Teixeira *et al.* used a battery of psychosocial measures of eating activity and body image related variables and how they changed between 0 and 12 months in 225 Portuguese women (Teixeira *et al.* 2010). The authors then related changes in behavioural variables to weight change at 12 and 24 months. Between 0 and 12 months, most measures of eating, activity and body image-related variables were related to weight loss. However, fewer of the same variables were significantly associated with weight maintenance at 24 months. Those that remained significant were flexible restraint, eating disinhibition, physical activity self-efficacy, physical activity perceived barriers, physical activity motivation, physical self-worth and body dissatisfaction (Teixeira *et al.* 2010). This again suggests that going from weight loss to weight loss maintenance leads to some shift in behaviours. Thus, it seems that as the weight loss journey proceeds, changes in physiology and behaviour begin to oppose the energy deficit. It is therefore to be expected that weight loss trajectories will both decelerate and show some tendency to rebound or relapse. Hence, weight loss programmes should evolve into weight loss maintenance strategies for the longer term (Franz *et al.* 2007). Weight loss is not a single point intervention from which the patient can walk away; it is a chronic relapsing condition that requires long-term management even when relatively extreme single-point interventions are used such as bariatric surgery (Odom *et al.* 2010; Sarzynski *et al.* 2011).

At the present time, it is not clear how the rate and extent of weight loss affect physiological signalling systems that compensate by reducing energy expenditure or increasing appetite. The maximum compensa-

tory decrease in energy expenditure is apparent from semi-starvation studies (Keys *et al.* 1950), mathematical modelling (Hall 2007; Hall 2010, 2012) and clinical studies (Leibel *et al.* 1995; Martin *et al.* 2007; Redman *et al.* 2009). There is still debate about the extent to which decreases in energy expenditure are due to decreases in metabolic body size, the energy cost of weight-bearing activities, muscular efficiency and how much can be attributed to flexible (adaptive) changes in resting metabolic rate and/or volitional activity. The impact of weight loss on hormonal signalling systems related to appetite and reward is not yet fully described. It is unclear if the same effects are apparent in those with severe obesity, compared with those who are moderately overweight. Neither is it clear how long such effects would last if weight were lost and then maintained at a lower weight. We do not know if men and women or specific ethnic groups differ in their responses or how variable inter-individual responses are. The answers to many of these questions would require extensive research comparing rate and extent of weight loss in groups with different starting weights over long periods of time and combining energy balance, body composition, physiological, metabolic, neuroendocrine, behavioural and psychological measures followed throughout the weight loss journey. Such studies would be invaluable for developing more effective weight loss and weight loss maintenance programmes for the future. To date, such strategies have rarely been articulated in comprehensive research programmes, although there are some exceptions (*e.g.* Keys *et al.* 1950; Martin *et al.* 2007; Redman *et al.* 2009). Instead, research has glimpsed facets of the relationship between body composition, physiology and behaviour in weight loss and subsequent maintenance. So there is much to learn about the dynamics underlying the transition from weight loss to weight loss maintenance or relapse. This raises the question, what are the behavioural strategies of successful weight loss maintainers?

### Behaviours associated with weight loss maintenance

The behaviours that are associated with weight loss overlap with and become the habits of, weight loss maintainers. However, it would appear that within-subject variability in behaviour change decreases as people develop the repeated behavioural patterns or habits of weight loss maintainers. It is possible to construct a league table of the behaviours associated with weight loss maintenance owing to the National Weight



**Figure 4** League table of weight control behaviours of successful weight loss maintainers in the National Weight Control Registry. Values are approximate because measures and numbers of registrants vary between publications over the 10 years of the registry's existence (Klem *et al.* 1997; Wyatt *et al.* 2002; Phelan *et al.* 2003; Wing & Phelan 2005; Phelan *et al.* 2006; Raynor *et al.* 2006).

Control Registry (NWCR) in the United States. The NWCR has been in existence for over 10 years and specifically recruits those who have lost more than 15 kg (although the average is ~30 kg) and maintained the loss for at least 12 months (Klem *et al.* 1997; McGuire *et al.* 1998; Wing & Hill 2001; Wing & Phelan 2005). There are now over 10 000 registrants (Fig. 4).

On top of the league table are diet and physical activity, followed by a range of behaviours that people employ as part of the lifestyle habits to maintain weight loss (Wing & Phelan 2005; Stubbs *et al.* 2011a). These behaviours vary considerably between individuals. The same general patterns of behavioural strategies are evident in the existing literature but resolution is not sufficient to put them in rank order (Jeffery *et al.* 1984; IOM 1995; Elfhag & Rössner 2005; Vogels *et al.* 2005; Kruger *et al.* 2006; Sciamanna *et al.* 2011; Stubbs *et al.* 2011a). Thus, key habits of successful weight loss maintainers include regular self-monitoring of weight, eating and activity behaviours (IOM 1995; Michie *et al.* 2009; Dombrowski *et al.* 2010; Stubbs *et al.* 2011a). Eating breakfast has been correlated with successful weight loss maintenance, although the exact mechanism is unclear (Wyatt *et al.* 2002). Limiting certain foods, consuming a low-fat, low energy-dense diet, and maintaining consistent eating patterns are all associated with weight loss

maintenance (Wing & Phelan 2005). Catching small slips before they become a major relapse, flexible rather than rigid restraint and planning are also associated with weight loss maintenance, as are well-being and social support (Stubbs *et al.* 2011a). Successful weight loss maintainers control their appetite and remain in a constant state of vigilance to ensure they do not overeat (Wing *et al.* 2008; Stubbs *et al.* 2012a). A very consistent and prevalent hallmark of successful weight loss maintainers is a high level of physical activity (Weinsier *et al.* 2002; Wing & Phelan 2005; Stubbs *et al.* 2011a). The range of behaviours exhibited by weight loss maintainers possibly suggests that different people achieve weight loss maintenance in generically similar (*i.e.* diet and physical activity) but specifically different ways (*i.e.* the specific behaviours). Indeed, the most recent analysis from the NWCR suggests that the behavioural strategies of weight loss maintainers fall into different clusters of behavioural strategies (Ogden *et al.* 2012). Half (50.5%) of the sample comprised of a weight-stable, healthy, physical activity-conscious group who had gone from a maximum body mass index (BMI) of 33.5 to 23.4, while 26.9% of the sample had always struggled with their weight and had gone from a maximum BMI of 44.7 to 28. The second cluster constantly struggled to maintain their weight, used the greatest number of

behaviour change strategies and sources of support and struggled more with their emotions. Within the NWCR sample, 12.7% succeeded at their first attempt, but had less weight to lose (from a BMI of 32.0 to 23.3), comprised of a higher proportion of males and had less of a history of weight and related health problems. A fourth cluster had changed their BMI from an average of 37.3 to 26.1, were older, did less physical activity, had a higher fat intake but ate fewer meals per day than the other three clusters (Ogden *et al.* 2012).

### **Behaviour change over the course of the weight loss journey**

As people progress through their weight loss journey, different individuals change various traits to differing degrees over time and so, behaviour changes associated with successful weight loss are complex, heterogeneous and dispersed over time (Stubbs *et al.* 2011a). Changes are not uniform across individuals or time, making them hard to measure or predict. Many people experiment with different behavioural solutions until they find pathways of behaviour change that best suit their lifestyles. Under these conditions, patterns of behaviour change are inconsistent and variable and can be characterised by repeated attempts.

In the post-weight loss or weight maintenance phase, there is evidence that successful weight loss maintainers settle into a new profile of behaviours, attitudes and psychological profiles that essentially keep them in a state of constant vigilance (Elfhag & Rössner 2005; Wing & Phelan 2005; Stubbs *et al.* 2011a). NWCR participants who have lost 30 to 35 kg have a 90% chance of relapse in the first one to two years. After five years, that risk is reduced to 30% (Wing & Phelan 2005). This implies that maintaining a new pattern of behaviours after weight loss decreases the risk of weight regain. A significant proportion of people do relapse and either regain weight or revert to strategies of attempted weight loss. Under these conditions patterns of behaviour change are inconsistent and variable for relapsers but less so for maintainers (Stubbs *et al.* 2011a). However, for weight maintainers, there is considerable inter-individual variability in behavioural strategies used (Wing & Phelan 2005; Ogden *et al.* 2012).

### **Weight relapse: physiology, emotion and behaviour**

The physiological changes that occur during the transition between weight loss and weight loss maintenance, if not managed by behaviour change strategies, will lead

to weight relapse. However, for the individual, the prism through which lapses and relapses in the weight loss journey are viewed is not one of physiology but of emotion and behaviour. Even successful weight loss maintainers have to remain vigilant and relapse is frequent (Phelan *et al.* 2003). The overarching predictor of relapse is a failure to build on and maintain the patterns of behaviours that led to weight loss in the first place (Stubbs *et al.* 2011a). Factors associated with weight regain include negative life events and family dysfunction, higher levels of depression and negative emotions, dietary disinhibition, small lapses, physiological cravings, impulsiveness and binge eating (Schlundt *et al.* 1989; Wing *et al.* 2008), infrequent physical activity, eating unconsciously in response to emotions, low use of available social support and avoidance of directly confronting problems (Kayman *et al.* 1990). Thus, relapse can be characterised by a cluster of traits that indicate a tendency to fail to adopt behavioural strategies that navigate around the physiological pull induced by an induced energy deficit.

These observations suggest that relapse avoidance and successful maintenance strategies involve developing skills and coping strategies in the domains of behaviour (*e.g.* diet and activity) and emotion (*e.g.* structure vs. impulsiveness, social support, finding solutions other than food as a means to cope with emotional perturbations). It seems that for successful weight loss maintainers, these behavioural changes (which begin during weight loss) become practiced until they become automatic default long-term habits. Even then, small lapses occur and require considerable effort to overcome.

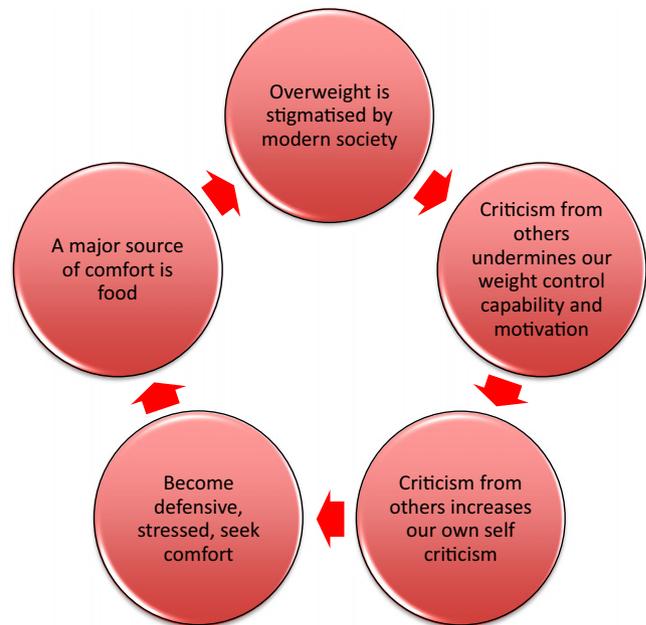
There is a large emotional dimension to relapse. Food is deeply embedded in the functioning of both our emotive and reasoned thoughts and actions (Stubbs *et al.* 2012b). This has consequences for the way we interact with food; the way we use food for social and emotive purposes and in the current environment; for our ability to form planned, reasoned behavioural pathways to manage energy balance by controlling our food intake and/or physical activity (Stubbs *et al.* 2012b). Modern society stigmatises the overweight and consumption of energy in excess of requirements (despite the fact we are designed to do so) (Rogge *et al.* 2004; Puhl & Heuer 2009; Puhl & Heuer 2010; Stubbs *et al.* 2012b). At the same time, marketing and the media offer food as a major source of comfort and soothing (Lieberman 2006). This creates an emotional conflict by putting the intentions of our planned weight management behaviours at odds with our physiological design, which is to eat in the face of plenty, to protect ourselves from uncertainty in the food supply (Stubbs & Tolcamp

2006; Stubbs *et al.* 2012b) and to respond to energy deficits by compensating energy intake and expenditure. Turner *et al.* emphasise the importance of low self-esteem as a trigger for relapse (Turner *et al.* 1995). A survey by Cachelin *et al.* of 3394 men and women found that women in particular rated depression, stress, low self-esteem and the need to avoid situations as the more important reasons for weight gain and were more likely to feel terrible in response to a relapse (Cachelin *et al.* 1998). Similarly, Byrne *et al.* identified characteristics associated with weight regain, namely, failure to achieve weight goals and dissatisfaction with weight achieved; tendency to evaluate worth in terms of weight and shape; a lack of vigilance with regard to weight control dichotomous thinking; and, a tendency to use food to regulate mood (Byrne *et al.* 2003).

Feelings of failure, stigma, self-criticism and shame may be key factors that influence whether a lapse becomes a relapse. As a stigmatised condition, obesity invokes criticism from others (Gilbert 2009; Stubbs *et al.* 2012b). Criticism from others undermines our weight control capability and motivation. Criticism from others increases our own self-criticism. Self-criticism stimulates emotional threat systems. A sense of threat leads people to become defensive, to be stressed and to seek comfort. A major source of comfort is food. Thus, when people experience a weight lapse, they can become trapped in a chaotic emotional cycle which derails strategies of planned behaviour. There is therefore a complex relationship between physiology, emotion and behaviour, which can affect strategies of weight loss and weight loss maintenance (Stubbs *et al.* 2012b) (Fig. 5). This raises the question of how best to scale solutions to weight management in the general population. Implementing behaviour change in the community requires expertise in engaging, motivating, guiding and encouraging healthy choices, and coping with lapses to support behaviour change until it becomes the basis of healthy habits.

### Scaling behaviour change solutions at the level of the community in the general population

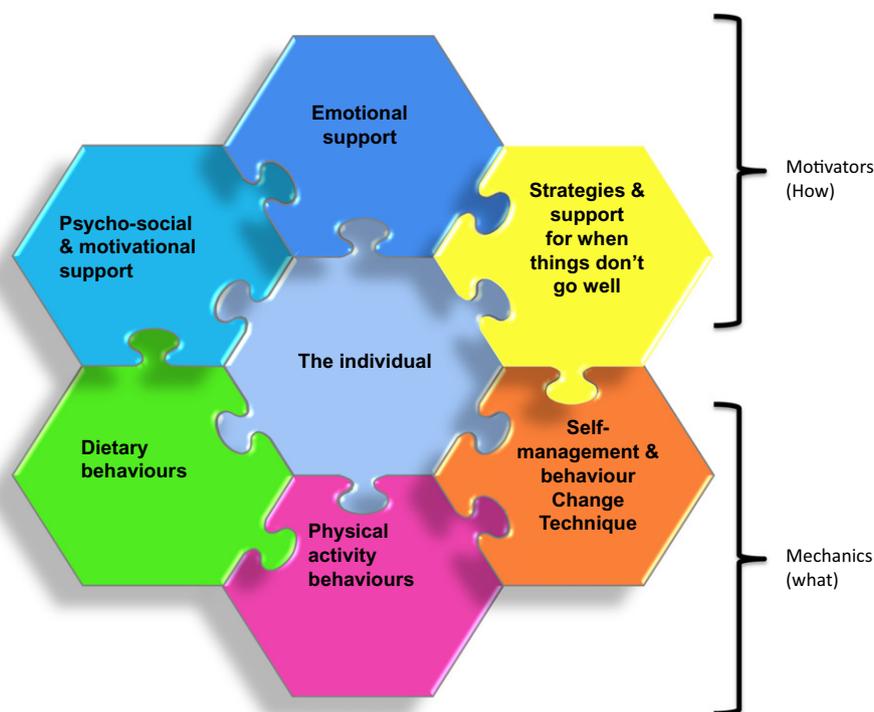
As an intensely social species, we solve many of our behavioural problems through social interactions. Informed choices are not enough (Cohen & Babey 2012). Similarly, behaviour change is too complex and heterogeneous to be shifted in the desired direction by a series of strategically placed nudges (House of Lords 2011). For many, weight loss trajectories are relatively precarious attempts at charting the course of planned



**Figure 5** How feelings of failure, stigma, self-criticism and shame may be key factors that influence whether a lapse becomes a relapse. People experiencing a weight lapse can become trapped in a chaotic emotional cycle, which derails strategies of planned behaviour (Gilbert 2009).

behaviour in the face of relatively strong opposing forces. Most people need guidance and support. There is growing evidence that community-based programmes which combine the mechanics of behaviour change with the key motivators for changing habits are effective as the first line in helping people adopt healthier dietary and activity patterns and in providing support to enable them to sustain these changes (Heshka *et al.* 2003; Bye *et al.* 2005; Lavin *et al.* 2006; Truby *et al.* 2006; The Counterweight Project Team 2008; Pallister *et al.* 2009; Ahern *et al.* 2011; Jebb *et al.* 2011; Jolly *et al.* 2011; Stubbs *et al.* 2011b). The mechanics of behaviour change are techniques involved in a programme, such as dietary behaviours, physical activity behaviours and specific behaviour change tools. They are the ‘what’ of behaviour change. The motivators of behaviour change are the psychosocial and motivational support, coping strategies and affiliative support for when things do not go well, identifying individual problems and personal solutions (Stubbs *et al.* 2012b). These are the ‘how’ of behaviour change. Both the mechanics and motivators of behaviour change need to be wrapped around the individual in a support structure with which they can engage as they need it (Fig. 6).

Dietary behaviours need to be relatively simple and manageable to the individual. They also need to be



**Figure 6** Key components of the mechanisms (i.e. dietary behaviours, physical activity behaviours, self-management and behaviour change techniques) and motivators (i.e. psychosocial and motivational support, emotional support and strategies, and support for when things do not go well) of behaviour change that are central to individual-focused, group-based weight management programmes.

sustainable so that weight loss can progress to longer-term weight-loss maintenance. Focusing on foods which are primarily traditional groceries, high in nutrient density but low in energy density, allows people to develop lasting dietary habits which pose minimum risk for weight regain and avoid hunger or ‘dieting’. These are foods such as fruits and vegetables, lean meat and fish, pasta, rice, potatoes, beans, lentils and low-fat dairy products (Stubbs *et al.* 2010). Key behaviours of weight loss maintainers are to limit, constrain and count high-risk foods and to navigate towards foods that will promote a healthy, balanced diet (Wing & Phelan 2005). However, for changes in dietary behaviours to be sustainable, people must give themselves flexibility and allow themselves some of the foods that are high risk for weight gain but which are deemed to be enjoyable. This has been called an 80:20 lifestyle (Golay, personal communication) and is practised by one commercial weight management organisation (Slimming World). By using current evidence relating to appetite and satiety, it is possible to navigate to healthier dietary habits that are sustainable and enjoyable in the long term (Stubbs *et al.* 2010).

Physical activity is not a good predictor of weight loss but is critical for weight loss maintenance, so it is important to promote a gradual increase in activity behaviours as the weight loss journey progresses. In this way, sedentary people can develop a commitment to behaviour

change so that the weight loss part of the journey is about becoming less sedentary and moderately active, while the weight loss maintenance component is about being habitually active (Stubbs *et al.* 2010). This approach enables people to build physical activity into their lives without it becoming an aversive shock to the system and puts current knowledge about physical activity into practice for the participants.

It is known that group support is more conducive to weight loss than currently available standard care (Heshka *et al.* 2003; Jebb *et al.* 2011). Although it is important to note that one-to-one comprehensive coaching and treatment can be very effective, it is extremely difficult to apply such resource-intensive treatment on the scale of the whole population; and, while it is known that group support is a vehicle for behaviour change, the exact mechanisms are less clear. Humans are intensely social animals and turn to social support for comfort, affiliation, to develop new skills and coping strategies, as well as to find a safe environment in which to learn to navigate toward a healthy body weight (Stubbs *et al.* 2012b). The impact of expert patient-led group support systems has become apparent for a variety of chronic relapsing conditions ranging from weight control, mental health, to drug dependency and HIV (Grimes & Cole 1996; Banks 1997; Citron *et al.* 1999; Humphreys & Ribisl 1999; Moos *et al.* 2001; Masudomi *et al.* 2004; Dongre *et al.* 2007;

Timko & DeBenedetti 2007; Powell & Perron 2010). These systems provide a mix of emotional and practical help according to individual need.

In terms of obesity, a dynamic expert patient-led group infrastructure can assist people in coping with stigma, criticism, self-criticism and hence relapse. Individual support in a structured group context nurtures self-efficacy, provides compassionate support, relates to individuals' problems and barriers, enables individuals to develop commitment for planned behaviour change, helps participants cope with self-induced or external 'sabotage' to weight management behaviours, and enables sharing of experiences, problems and solutions. Expert patient-led groups can help people cope with both the emotional and physical burdens of being overweight by creating a dynamic where participants can solve common problems, support each other emotionally and develop behaviour change skills that they then take away with them, fostering autonomy and self-efficacy (Humphreys & Ribisl 1999). In this way, they find solutions and support for their issues and concerns, which they can then pass on to their own social networks (*e.g.* families and friends). This is important because studies show that those who successfully maintain weight loss in the long term are the people who find their own solutions that suit their specific lifestyles (Elfhag & Rössner 2005; Wing & Phelan 2005; Stubbs *et al.* 2011a; Ogden *et al.* 2012) (*i.e.* they find ways that work for themselves as individuals). This is part of the answer to the heterogeneity of the obesity problem, by providing solutions that go beyond the one-size-fits-all approaches such as low-fat diets or physical activity (Ogden *et al.* 2012). Individualised support in a group context is one of the solutions to scaling weight management approaches across the whole population in a cost-effective manner.

It is almost axiomatic that diet and lifestyle group-based programmes will not work for everyone and that the obese population needs to be offered a balanced portfolio of behavioural and other solutions. However, in terms of delivering large-scale solutions in a cost-effective and scalable manner, these approaches have considerable potential for the implementation of behaviour change, data gathering and further refinement, based on the evidence obtained from them.

## Summary and conclusions

Weight loss is a difficult journey often characterised by repeated faltering attempts. Weight loss induces changes in physiological and emotional systems, which tend to pull people back to where they came from and create a

behavioural challenge for those attempting to lose weight and maintain the loss. Weight loss decreases fat and fat-free mass. Fat loss triggers hormone cascades that may influence appetite and weight regain. Loss of fat-free mass decreases several components of energy expenditure. Paths of behaviour change to promote weight loss are trodden across shifting physiological sands, which may influence (and undermine) the actual behaviours people are trying to change. Currently, it is unclear how rate, extent, or the type of weight loss impact on signalling systems that can oppose weight loss, as well as how these changes affect emotion, behaviour and weight outcomes. This is an important area for future enquiry.

Changes in eating behaviour appear to be more important for weight loss earlier in the weight loss journey, while physical activity becomes an important additional behavioural strategy to support changes in dietary behaviour during weight loss maintenance. A range of weight-loss behaviours characterise weight loss and its maintenance. There may be differing clusters of behaviours, which characterise weight loss compared with weight loss maintenance, and there appear to be different clusters of behaviours that characterise weight-loss maintainers.

There is evidence that successful weight loss maintainers adapt and transform the initial behaviours of weight loss into those of weight maintenance so that they become autonomic and habitual. However, most remain in a constant state of vigilance with respect to self-monitoring and relapse prevention. Relapse is not infrequent. The overarching characteristic of relapse is a failure to build on and maintain the patterns of behaviour that led to weight loss in the first place. Relapse is characterised by environmental, psychosocial and/or emotional triggers that undermine the capability, motivation and opportunity to map paths of planned behaviour from the process of change to the development of new habits.

To proceed along the difficult journey of weight loss to one of habitual weight loss maintenance requires long-term self-management. Environments and programmes that support, nurture and facilitate long-term behaviour change give people the capability, the opportunity and the motivation to navigate to a healthy weight.

## Conflict of interest

The authors, Dr James Stubbs and Dr Jacqui Lavin are employed by Slimming World. Slimming World is a commercial weight management organisation specialising in behaviour change.

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