THE IMPACT OF EATING SELF-REGULATORY SKILLS ON WEIGHT CONTROL AND DIETARY BEHAVIOURS IN ADULTS

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UCL

DECLARATIONS

I, Nathalie Kliemann, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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ABSTRACT

Recent studies suggest the ability to self-regulate eating behaviour may help people to cope with the food environment and achieve, as well as maintain, a healthy weight and diet. However, most studies exploring the relationships between eating self-regulatory skills, weight control and dietary habits in adults have used a cross-sectional design and have not accounted for the full range of eating self-regulatory skills, possibly due to the fact that no comprehensive measure of eating self-regulation exists. Furthermore, although there are indications that eating self-regulatory skills may be enhanced through practice, the most effective way to improve these skills and the impact of any changes on weight loss and dietary behaviours has not been established. Therefore, this PhD thesis developed a valid and reliable measure to assess eating self-regulatory skills in the general adult population (Study 1). Results from Study 2 showed that higher eating self-regulatory skills may help students to maintain or achieve a healthy diet and protect them against substantial weight gain (≥5% initial body weight), especially among students with higher BMIs. In Study 3, secondary analysis from the 10 Top Tips (10TT) randomised controlled trial was undertaken to test the effect of a habit-based intervention on eating self-regulatory skills. Results showed 10TT promoted greater increases in self-regulatory skills than Usual Care. Furthermore, these changes in self-regulatory skills mediated the effect of 10TT on target behaviours and weight loss. Lastly, since the use of new technology for lifestyle interventions is an emerging field in public health, two app versions of 10TT, one identical to 10TT (Top Tips ‘only’ app) and another including a self-regulatory training component for breaking unhealthy eating habits (Top Tips ‘plus’ app), were developed and piloted with overweight and obese adults (Study 4). Exploratory results from Study 4 suggest that both app interventions may promote eating self-regulatory skills, weight loss and healthy behaviours among overweight and obese adults, especially among those more engaged with the apps. However, both apps would benefit from further development work and should be evaluated by means of a randomised controlled trial.

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ABBREVIATIONS

NDNS	National Diet and Nutrition Surveys
BMI	Body Mass Index
HAPA	Health Action Process Approach
FFQ	Food Frequency Questionnaire
SCS	Self-Control Scale
PSSDS	Perceived Self-Regulatory Success in Dieting Scale
SREBQ	Self-Regulation of Eating Behaviour Questionnaire
SRQ	Self-Regulation Questionnaire
F&V	Fruit and Vegetable intake
SSS	Sweet and Salty Snacks intake
SS	Sweet Snacks intake
SD	Sugary drinks intake
10TT	Ten Top Tips Trial

CHAPTER 1: BACKGROUND TO SELF-REGULATION OF EATING BEHAVIOUR

The overall aim of this thesis was to test the hypothesis that eating self-regulatory skills help to maintain and achieve a healthy diet and weight and can be enhanced through habit-based weight loss interventions. To address this, in this first chapter I introduce the background to eating self-regulatory skills and contextualize eating self-regulatory skills within the current obesogenic environment. I also cover the main definitions and theoretical models of self-regulation as well as the processes and abilities involved in the successful self-regulation of eating behaviours.

1.1 Eating self-regulatory skills in the context of the obesogenic environment

Opting for a balanced diet has significant health benefits including protection against a range of non-communicable diseases (WHO, 2015a). A healthy diet is typically characterised as being rich in fruit, vegetable and wholegrain foods and low in saturated fat, trans-fat and salty and sugary foods (Nestle, 2007; WHO, 2004; Willett & Stampfer, 2013). Specific dietary guidelines have been established for the UK adult population, as shown in Table 1 (SACN, 2008, 2010, 2015). However, according to the British National Diet and Nutrition Survey (NDNS), the diets of the majority of British adults do not meet most healthy dietary requirements. Results of the NDNS showed that on average the adult population eats less than the recommended amount of fruit and vegetables (<5 portions/day), oily fish (<140g/week) and wholegrain foods (<18g/day of fibre) and exceeds their consumption of saturated fat (>11% of food energy), free sugars (>5% of food energy), and salt (>6g/ day) (PHE & FSA, 2016; PHE & FSA, 2016).

Table 1.1 Nutritional recommendation and actual dietary intake for the UK adult population

Food/nutrient	**UK recommendation**[1]	**Adult intake**[2]
Red and processed meat[a]	Max. 70g/day	65g/day
Oily fish[b]	At least 140g/week (~1 portion)	54-87g/week
Fruit and vegetables	At least 5 portions/day	4 portions/day
Wholegrain foods (fibre)	>18g/day	14g/day
Salt	<6g/day (<2.4g sodium/day)	8g/day
Total fat	<35% food energy	34.2% food energy
Saturated fat	<10% food energy	12.7% food energy
Trans fat acids	<2% food energy	0.5% food energy
Free sugars	<5% food energy	7-9% food energy

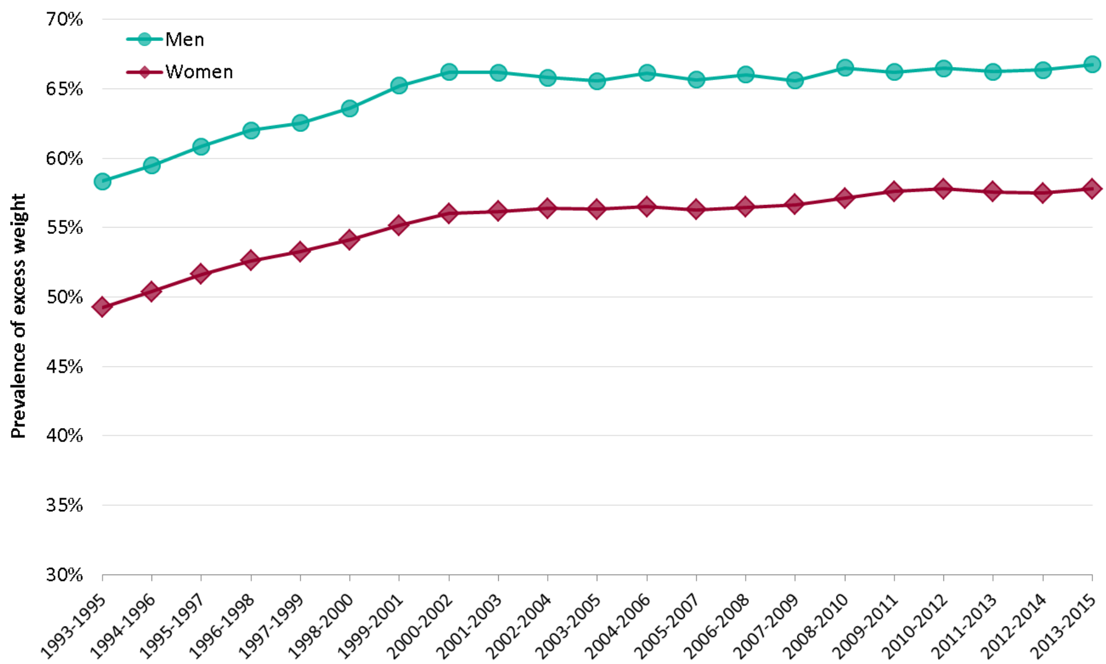
Note= [a]Red and processed meat includes beef, lamb, pork, sausages, burgers and kebabs, offal, processed red meat and other red meat. [b]Oily fish includes anchovies, carp, trout, mackerel, herring, jack fish, pilchards, salmon (including canned), sardines, sprats, swordfish, tuna (fresh only) and whitebait.

Source= [1]Recommendation from the Scientific Advisory Committee on Nutrition (SACN, 2008, 2010, 2015). [2]UK National Diet and Nutrition Surveys years 5 and 6 (2012-2013 – 2013/2014) – data for adults from 19 to 64 years old (PHE & FSA, 2016).

A large body of evidence suggests that these unhealthy dietary patterns are mainly driven by the current obesogenic environment – that is, an environment rich in palatable and inexpensive food, usually served in large portion sizes, with a high energy, salt and sugar content and low nutritional value (French, Story, & Jeffery, 2001; Malik, Willett, & Hu, 2013). Eating out at restaurants, fast food venues and cafes has risen rapidly since the 1970's and has been linked to the consumption of foods higher in energy density (French et al., 2001). The manufacture and supply of processed foods, such as ready-to-consume products, has also expanded across the globe. Processed foods, which are typically highly profitable for the industry and unhealthy (Monteiro, 2009), are replacing food systems and dietary patterns based on natural and minimally processed foods (Moodie et al., 2013). These changes in the marketplace and food production, as well as sophisticated food marketing, hinder people's ability to make healthier food choices (Contento, 2008). Indeed, a cross-sectional study conducted in the United Kingdom (UK) showed that a greater exposure to fast food outlets, especially at work, was related to a greater consumption of takeaway foods (Burgoine, Forouhi, Griffin, Wareham, & Monsivais, 2014). Another study found that ready-to-consume processed foods represent on average 63% of the total dietary energy in the UK and have a relative cost (cost per Kcal) 43% lower than the rest of the diet (Moubarac et al., 2013). The impact that this can have on people’s health is alarming as, according to a recent study using data from the UK NDNS, a higher processed food intake was related to a higher sodium, fat, saturated fat and sugar intake and lower fruit and vegetables, fibre and protein intake (Adams & White, 2015).

Changes in dietary behaviours combined with increased sedentary lifestyles have promoted a positive energy balance (Malik et al., 2013; WHO, 2004). Although reduction in physical activity has an important role to play in promoting weight gain, this thesis will mainly focus on the impact of changes in dietary behaviours. Overweight and obesity, defined as an abnormal or excessive fat accumulation, have increased worldwide and are major risk factors for chronic diseases such as type 2 diabetes mellitus, cardiovascular disease and some cancers (Finucane et al., 2011; WHO, 2014). Global obesity rates have more than doubled in the last 35 years (WHO, 2015b). In 2015, nearly 600 million adults worldwide were obese (Afshin et al., 2017). In England, the prevalence of overweight and obesity increased significantly from 1993 to 2015, remaining stable since then in both men and women (Figure 1). Currently, around 66.8% of men and 57.8% of women are either overweight or obese and the rates tend to increase from early to older adulthood, reducing among elderly people (HSCIC, 2017).

Figure 1.1 Trends in overweight and obesity among adults in England



Source= Statistics on Obesity, Physical Activity and Nutrition (HSCIC, 2017)

However, even though the modern environment promotes unhealthy lifestyles, there is still significant individual variability in adiposity and dietary behaviours, suggesting that environmental cues do not affect all people similarly (Wardle & Boniface, 2008). Over the past few years, research studies have established that some people are more genetically predisposed to become obese in the current food environment (Llewellyn & Wardle, 2015). The interaction between genes and environment has been demonstrated in recent studies showing that the greatest weight gain in adults has been concentrated at the higher end of the weight distribution, while thinner people have remained thin (Kautiainen, Rimpela, Vikat, & Virtanen, 2002; Wardle & Boniface, 2008). Also, the effect of obesity genes seems to be greater in a more obesogenic environment (Llewellyn & Wardle, 2015).

In an attempt to better understand the interaction between genes and environment, the Behavioural Susceptibility Theory, was developed. This is an appetitive model of obesity that aims to explain how genetic risk to obesity might be expressed in terms of appetitive traits[1], and their associated eating behaviours, across the weight continuum (Carnell & Wardle, 2008; Llewellyn & Wardle, 2015). Prospective studies conducted with twin samples support the idea that appetitive traits, such as satiety sensitivity[2] and responsiveness to food cues[3], have a genetic basis and play a causal role in weight gain and dietary behaviours during early infancy (Syrad, Johnson, Wardle, & Llewellyn, 2016; van Jaarsveld, Boniface, Llewellyn, & Wardle, 2014; van Jaarsveld, Llewellyn, Johnson, & Wardle, 2011). However, genetic influence on weight varies with age and is stronger among children compared to adults (Elks et al., 2012). In line with this proposition, a study found that the associations between appetitive traits and Body Mass Index (BMI) in adults were less strong compared to those found in children (Hunot et al., 2016). This difference may be a result of adults applying self-regulation over their eating behaviour in order to control their weight and diet (Llewellyn & Wardle, 2015; Wardle, 2009). In brief, eating self-regulatory skills refer to the ability to control behaviour, thoughts, feelings and attention in the service of long-term eating goals (Carver & Scheier, 2001; De Vet et al., 2014). For example, the ability to inhibit a desire to have a sweet in order to stay healthy (for a more detailed description of self-regulation see section 1.3).

Recent studies have suggested that eating self-regulatory skills may be an important individual factor that helps individuals to cope with the obesogenic environment and achieve, as well as maintain, a healthy weight and diet (de Wit et al., 2015; Johnson, Pratt, & Wardle, 2012; Kroese, Evers, & De Ridder, 2009). It has been argued that eating self-regulatory skills can help people to find a balance between their long-term diet goals and the immediate pleasure of palatable and unhealthy food (Johnson et al., 2012; Kroese et al., 2009). Moreover, self-regulatory skills have been consistently related to positive behavioural characteristics, such as academic

[1]Appetitive traits are defined as a set of stable predispositions towards food (Carnell & Wardle, 2008).

[2]Satiety sensitivity is the ability to recognise and respond to internal sensations of fullness or satiety (Carnell & Wardle, 2008)

[3]Food responsiveness is defined as the response to external food cues such as the sight or smell of food (Carnell, Haworth, Plomin, & Wardle, 2008)

performance (Duckworth & Seligman, 2005), financial management (Romal & Kaplan, 1995) and healthy behaviours (Bogg & Roberts, 2004; Schroder & Schwarzer, 2005).

Although solutions to obesity need to be multifaceted, due to the complexity of its determinants, interventions that promote skills for the self-regulation of eating behaviour are attracting increasing attention as a promising approach for the prevention and treatment of obesity (Bandura, 2005; Johnson et al., 2012; Miller et al., 2012). There is no doubt that the environment needs to be changed to increase opportunities for healthy eating and physical activity. However, it is unlikely that we will ever return to an environment in which no self-control will be required to maintain healthy behaviours (Hill, Wyatt, Reed, & Peters, 2003). Increasing the availability of healthy food options, labelling, taxation, subsidies and price adjustments to food are all relevant to supporting healthy food choices. However, inevitably, promoting healthy eating leaves each individual with the challenge of making the healthier choices (Malik et al., 2013; Wardle, 2006). Promoting self-regulatory skills could potentially help people to deal with the current food environment and make healthier decisions as well as control their weight.

1.2 Eating self-regulatory skills and the Restraint Theory

Although there is an increasing interest in self-regulatory skills, the proposition that these skills are relevant for building healthy eating habits and weight control is still controversial due to the dominance over the past 40 years of restraint theory (Herman & Mack, 1975; Johnson et al., 2012). Laboratory studies conducted in the 1970’s suggested the intention to eat less in order to stay in shape (Herman & Mack, 1975) was the cause of disinhibition (Johnson et al., 2012) – that is, the tendency to overconsume in response to a stimulus, such as emotional distress or the presence of tempting foods (Hays & Roberts, 2008). These results led to the development of ‘Restraint theory’, which states that cognitive control over eating behaviour may result in overeating in situations where control is undermined, referred to as ‘counter-regulation' (Annesi, Porter, & Johnson, 2015; Cools, Schotte, & Mcnally, 1992; Herman & Mack, 1975; Herman & Polivy, 1975; Hibscher & Herman, 1977). However, the validity of this theory was soon questioned due to the publication of conflicting results. Researchers have suggested that some scales, such as the Restraint Scale (Herman & Polivy, 1975), assess a range of personality traits and eating tendencies (such as the susceptibility to overeat and weight fluctuation) rather than the intent to exercise dietary restraint, and that this may have contributed to mixed results (Laessle, Tuschl, Kotthaus, & Pirke, 1989; Williamson et al., 2007). Taking this into account, it seems probable that the counter-regulation (and weight gain) seen in some dieters may be a direct result of disinhibition rather than being mediated via restraint (Johnson et al., 2012; Meule, Papies, & Kubler, 2012; Wardle, 2006).

As a result, researchers have developed psychometric scales assessing just dietary restraint and no other traits, but this has not solved the issue of inconsistent results for the relationship with weight control (Johnson et al., 2012; Williamson et al., 2007). In order to explore the features associated with the mixed results, the restrained eating construct in the Three Factor Eating Questionnaire (a commonly used measure of eating behaviours (Stunkard & Messick, 1985)) has been broken down into two subscales, rigid and flexible control. Rigid control was characterized as a strict all-or-nothing approach to eating (e.g. 'Sometimes I skip meals to avoid gaining weight'), and flexible control was defined as a malleable approach to eating (e.g. 'If I eat a little bit more on one day, I make up for it the next day') (Westenhoefer, Stunkard, & Pudel, 1999). A cross-sectional study using this questionnaire showed that even though the two subscales were significantly correlated, rigid control was associated with higher BMI, while flexible behaviour was related to lower BMI (Westenhoefer et al., 1999). Laboratory and field studies have supported these results, as shown in a review by Johnson et al. (2012). The review also indicated that a flexible approach to eating may help differentiate individuals who can achieve their weight goals from those who may fail (Johnson et al., 2012). Thus, recent studies suggest that the ability for making adjustments, an important self-regulatory skill, may be a key difference between dieters who successfully achieve their goals (i.e., lose weight or change their diet) and unsuccessful dieters (Johnson et al., 2012; Phelan et al., 2009). Therefore, a greater understanding of the role of self-regulatory skills in people's ability to achieve and maintain a healthy weight and diet, as well as how to improve these skills could increase understanding of why people's weight management efforts are successful or not and, in turn inform interventions in this area.

1.3 Conceptualizing self-regulation of eating behaviour

To facilitate the review and synthesis of studies exploring the impact of self-regulatory skills on weight control and dietary behaviours and how these could be enhanced, it is helpful first to briefly conceptualize self-regulation more generally and understand its theoretical background.

1.3.1 Definition

The term 'self-regulation' has been used in the literature to refer to different things, from biological regulation of blood pressure to movement control (Carver & Scheier, 2001). In this thesis, it relates specifically to the regulation of 'behaviour' defined as 'anything a person does in response to internal or external events' (Michie & West, 2013).

Behavioural self-regulation is one of the central concepts in psychology and refers broadly to the multicomponent process of goal-directed behaviours (Baumeister, Gailliot, DeWall, & Oaten, 2006). It is often conceptualized as the individual's ability to alter their behaviour, thoughts, feelings, attention and environment in the pursuit of their personal goals (Boekaerts, Maes, & Karoly, 2005; Carver & Scheier, 2001; De Vet et al., 2014; Moilanen, 2007). Therefore, self-regulation is a process that aims to bring individuals' actual behaviour in line with their goal aspirations (Carver & Scheier, 2011). Behavioural self-regulation is likely to be a relatively stable construct

(Hagger, 2014), but one that can be improved through practice (Hofmann, Schmeichel, & Baddeley, 2012; Johnson et al., 2012) as discussed in section 1.3.3.

Self-regulation when applied to eating behaviours refers to the psychological and behavioural processes involved in the pursuit of eating goals. However, the concept of goals is very broad, allowing differences in goals' temporal commitment and level of abstraction, which may have implications in terms of the process of self-regulation involved. Some goals are very focused (e.g. perform well in a specific eating task), while others are broader in focus (e.g. have a healthy lifestyle) (Carver & Scheier, 2001). This thesis is specifically concerned with the eating self-regulatory skills[4] involved in the pursuit of long-term healthy dietary and weight control goals. These complex behavioural goals are very challenging since they require a long-term commitment (potentially indefinite), as well as the inhibition of short-term eating goals that are not in line with the long-term goals standards. Therefore, self-regulatory skills in the context of healthy dietary behaviours and weight refer to the individual's ability to manage their eating behaviour and override their natural impulses toward tempting foods in order to achieve and maintain a healthy diet and weight.

Traditionally, self-regulation has been seen as a reflective process, where the 'self' is an active agent, who pilots the behaviour (Papies & Aarts, 2011). However, goal-directed behaviours can also be driven by automatic processes (Aarts, Custers, & Holland, 2007; Bargh & Williams, 2006; Carver & Scheier, 2001; Marteau, Hollands, & Fletcher, 2012). Automatic actions and behaviours are those controlled by external stimuli or events, and may happen without conscious awareness (Bargh & Williams, 2006; Papies & Aarts, 2011). It has been argued that people do not always have conscious access to the goals that drive their complex behaviours and that they can even deal with temptations automatically (Forster & Jostmann, 2012). Reflective processes may overlap or interact with automatic processes for goal-directed behaviours (Presseau et al., 2014). External stimuli may automatically bring to mind

[4]Skills are defined as an ability or proficiency acquired through practice (Cane, O'Connor & Michie, 2012).

the goal of the action which may help the individual to attain their intended behaviour. The behaviour that emerges may be noticed by the individual, giving the sense of self-agency, while the link between the cue and the behaviour may occur outside awareness (Marteau et al., 2012). For example, watching a fruit juice advertisement on television may prime the goal of eating fruit and consequently lead to its consumption. These procedural priming effects only represent automatic self-regulation when they elicit individuals' goals and help goal pursuit, as sometimes they may represent mechanical and cognitive processes stored in memory (e.g. take the lift when you actually wanted to take the stairs) (Forster & Jostmann, 2012). The automatic process that generates an impulse toward action, based on learned stimulus-response association, is defined by Gardner (2015) as habit.

In the literature, the terms self-control and self-regulation are frequently used interchangeably. Self-control refers to the ability to inhibit dominant responses tendencies or desires in order to attain a personal goal (Carver & Scheier, 2011; De Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). Therefore, it deals with goal conflicts, when moving toward one goal means going away from another one (Forster & Jostmann, 2012). However, not all self-regulatory efforts involve goal conflict, (Carver & Scheier, 2001; Forster & Jostmann, 2012; Fujita, 2011), for instance, maintaining an intended healthy habit. The term self-regulation is also used inter-changeably with self-management in many research studies. However, self-management is conceptualized by many authors as the application of processes of self-regulation (Monique Boekaerts, Pintrich, & Zeidner, 2005). Thus, in the present thesis, both self-control and self-management are viewed as part of the self-regulation construct but not identical to it, as self-regulation encompasses a broader variety of skills and processes than self-management and self-control do (See the glossary in Appendix 1.1 for a list of key terms and definitions).

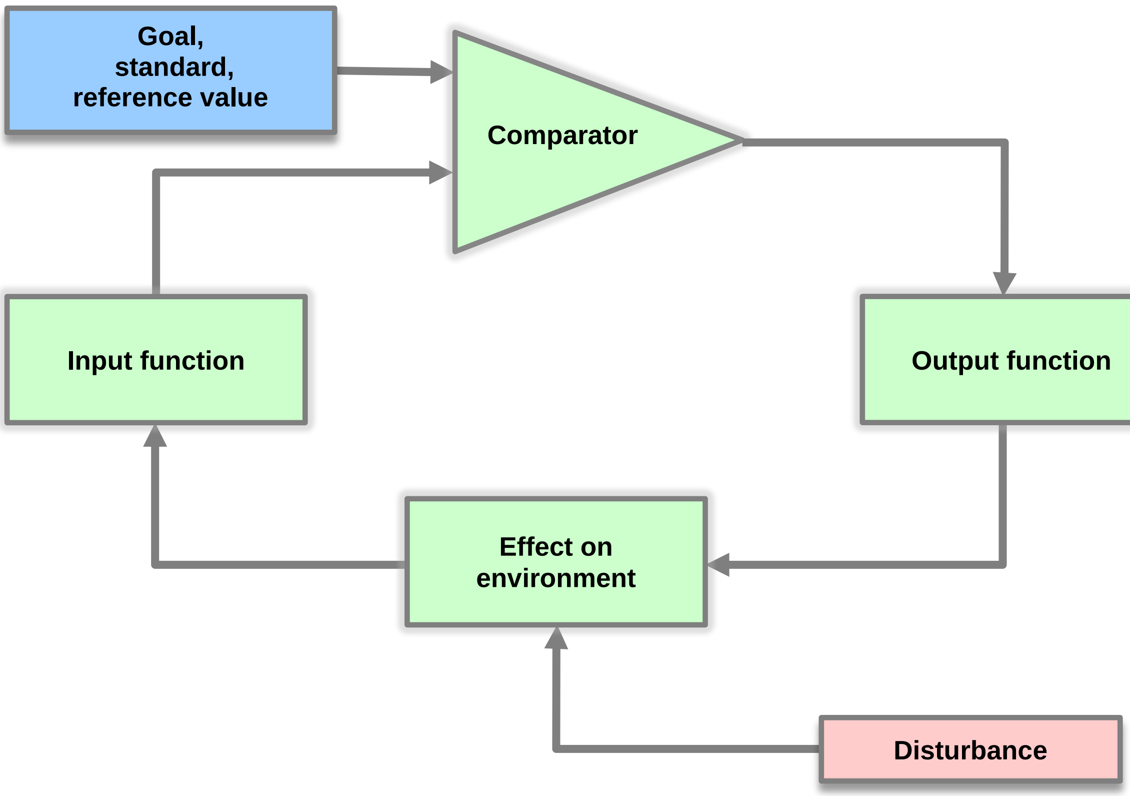
1.3.2 Theoretical models of self-regulation

Over past decades, advances in cognitive and social-personality psychology research have significantly contributed to our knowledge about the processes and underlying ability of the self-regulation of behaviour. Even though the definition of self-regulation seems to be quite consistent in the literature, the specific mechanisms by which self-regulation operates and its principles vary according to different theoretical models of self-regulation. Although self-regulation is an element present in many models of psychological processes, four of the most influential theories that explicitly explain the process and abilities involved in the self-regulation of behaviour are described below.

1.3.2.1 Feedback-loop model of self-regulation

The feedback-loop model of self-regulation is one of the leading theories in the field of self-regulation and was first proposed by Carver and Scheier in 1982 (Carver & Scheier, 1982; Carver & Scheier, 2001). In this model, self-regulation is conceptualized as a process of establishing goals and adjusting patterns of behaviour to attain those goals, using informational feedback as a guide (Rasmussen, Wrosch, Scheier, & Carver, 2006). This purposive process involves four elements: 1) The reference point, which is the goal being pursued; 2) the input function, which is the perception about how you are doing; 3) the comparator, which gives the information about progress as it compares the input with the reference value; and 4) the output function, which is the actual behaviour (see Figure 1.2). The self-regulation process aims to achieve and maintain a sense of conformity between the actual behaviour and the reference value (Carver & Scheier, 2001). The feedback loop can be negative or positive. In the negative feedback loop, the objective is to remove or diminish a discrepancy between input and reference value (e.g. increase vegetable consumption). While, in the positive feedback loop the objective is to amplify the discrepancy between the input and the reference value or undesired goal (e.g. cut down on chocolate). However, the authors argue that usually the best strategy to avoid an unwanted behaviour is by approaching something else (Rasmussen et al., 2006). In this perspective, discrepancy-enlarging loops can be replaced by discrepancy-reducing loops. For instance, to cut down on chocolate after lunch, people may aim to have a piece of fruit instead. The authors also emphasize that in some domains, such as healthy behaviours, self-regulation is a continual process of establishing goals and adjusting patterns of behaviors to match those goals more closely. In these domains, goals (reference points) are progressive rather than fixed (Carver & Scheier, 2001).

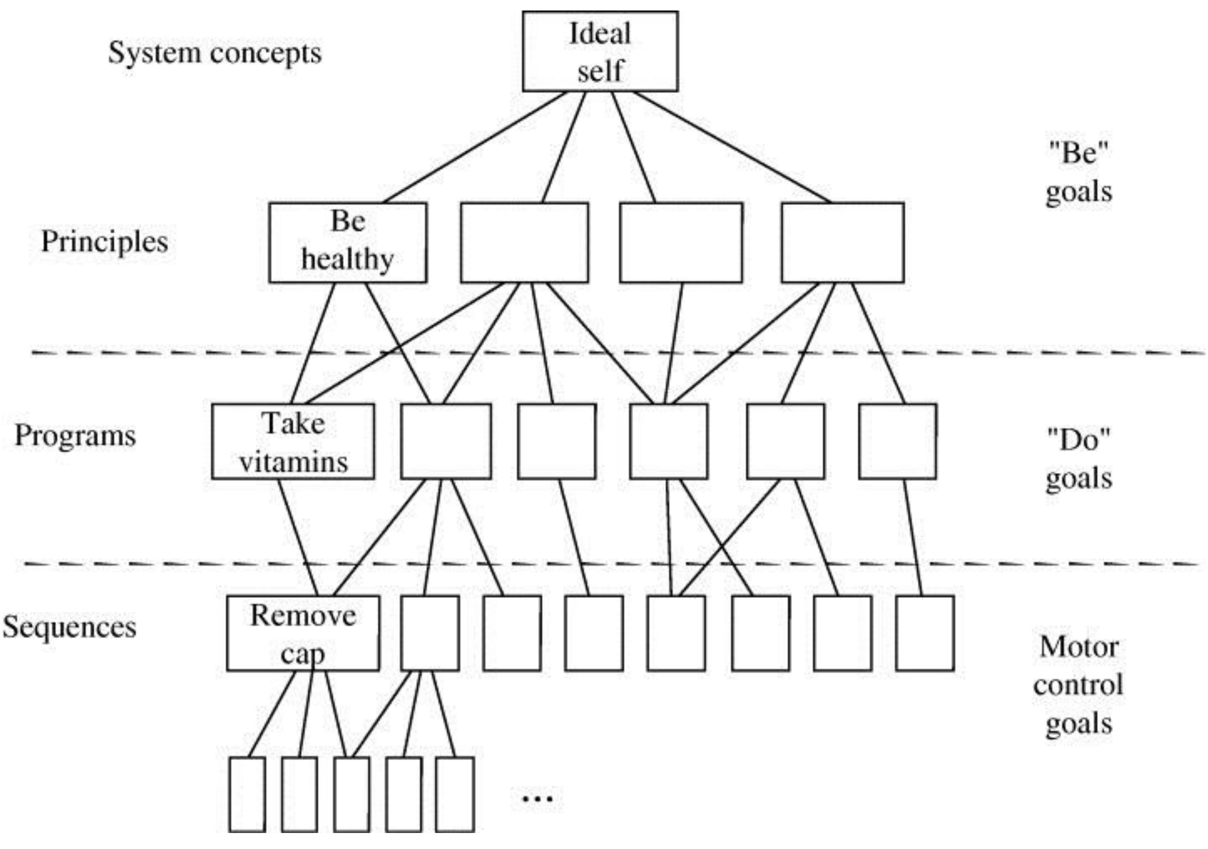
Figure 1.2 Schematic depiction of the feedback loop process of self-regulation



Source= Rasmussen et al. (2006)

They also reason that a hierarchical organization of feedback loops underlies the model, where there are subordinate and superordinate loops (Carver & Scheier, 2001). This may be of great relevance to understanding the self-regulation of complex behaviours which involve sequential sub-goals (e.g. buy fruit and vegetables) that need to be achieved in order to achieve the overall goal (e.g. eat 5 fruit and vegetables every day). The authors suggest that higher-order systems serve as a reference value for the systems below them, and each level may be adjusted to its own discrepancies. For example, higher-order goals of ‘being’ (e.g. be healthy) specify more concrete goals of ‘doing’ particular actions (e.g. eat more salad at lunch time), referred to as ‘program-level control’ (see figure 1.3). Much of day-to-day activity, such as ‘cooking dinner’ and ‘having breakfast every day’ are considered programs. The model also suggests that by enacting a program, people need to partly enact a sequence of movements. However, when an action is performed consistently and its enactment become more automatic, it can be seen more as a sequence than as a program. As a result, attaining lower level goals and making them become more automatic, helps to achieve higher level ones (Carver & Scheier, 2001).

Figure 1.3 Hierarchy of goals of feedback loops



Note= This graph omits some elements of the feedback loop to illustrate how these different goals are connected.

Source= Rasmussen et al. (2006)

Although this model has been helpful to elucidate the components present in the process of self-regulation of complex behaviours, it lacks information on the underlying abilities required for effective self-regulation. It also does not cover the process of dealing with challenges that people may face while trying to change or maintain a behaviour, a common issue within the pursuit of eating more healthily. Additionally, although this model has been applied to explain self-regulatory skills required for dealing with health threats (Rasmussen et al., 2006), I have not found evidence of its application in the eating behaviour domain.

1.3.2.2 Social Cognitive Theory of Self-Regulation

The Social Cognitive Theory of Self-Regulation was put forward by Bandura (1991) and states that through the exercise of forethought people influence their own motivation and self-direct their behaviour using self-regulatory mechanisms. In line with Carver and Scheier’s model, this theoretical view suggests that the main self-regulatory mechanisms are the adoption of goals and planning a course of action, self-monitoring the behaviour, and self-reaction influences (Bandura, 1991, 2005). Goals work as guides for the process of self-regulation (e.g. eat salad at lunch time). In order to influence actions, self-monitoring behaviour is essential, as it provides information on performance (e.g. how many times they are meeting their eating goal) and on determinants, that is - the cognitive conditions under which people engage in a specific behaviour. This source of information helps the self-diagnostic function of self-regulation, where people get insights into how they are progressing and what they should do in order to improve. As a result of this, people may set strategies and plans to achieve the intended behaviour. Self-reactive influences are the incentive and support required to sustain the intended behaviours. Bandura (2005) argued that the establishment of self-rewards contingent upon goal progress and the monitoring of successes rather than failures can promote greater efforts to reach the goal. In addition, the model suggests that in the exercise of self-directedness people exert control over their feelings, thoughts, motivation and actions. However, no further explanation of these abilities is provided, nor whether they can be improved through practice. Also, although plans and strategies are mentioned as part of the self-reactive process, no attempts to explain how people should set up plans and goals in order to successfully regulate their behaviour have been made.

This model has proven particularly important for the discussion of the influence of self-efficacy beliefs, that is - people's belief in their ability to achieve a goal, on self-regulatory actions. This theory posits that goal striving is governed by individual's self-efficacy beliefs and that people undertake actions that they judge themselves capable of doing (Bandura, 1991). However, this thesis understands self-efficacy as a determinant of self-regulatory skills, but not necessarily part of the self-regulatory process.

1.3.2.3 The strength model of self-regulation

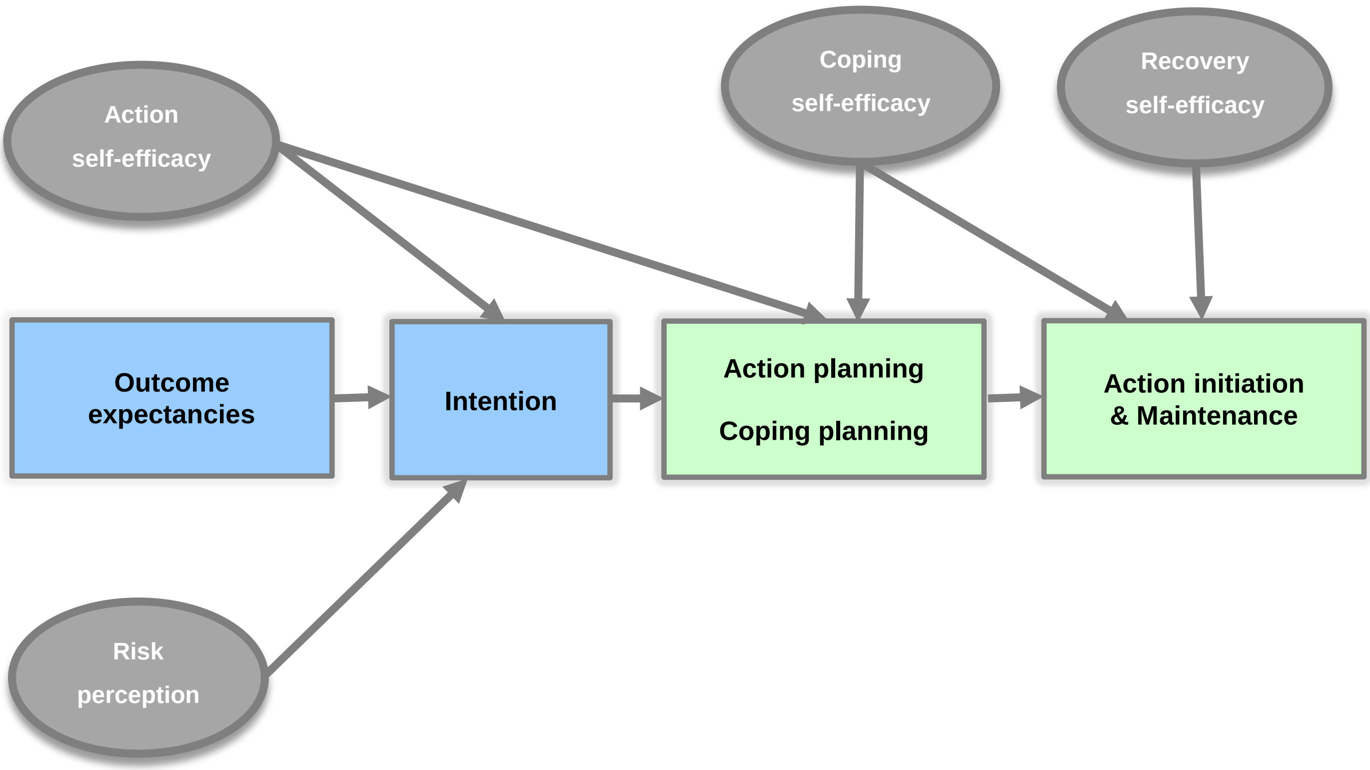
Whereas the previous models highlight the process of self-regulation, Baumeister's strength model (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister, Vohs, & Tice, 2007) emphasises the resources required in order to make changes and adjustments to one's behaviour and achieve a goal. As such, this can be seen as a complementary model since it focuses on different aspects of self-regulation. The model suggests that self-regulation relies on a set of limited inner resources to operate, similar to energy or strength (Muraven & Baumeister, 2000). When these resources are diminished, as a result of prior engagement in self-control effort, people become temporarily vulnerable to self-regulatory failure in their subsequent self-control attempt: so-called 'Ego depletion' (Baumeister, 2016; Baumeister et al., 2007). However, this suggestion has been the subject of considerable debate in the literature (De Ridder et al., 2012). As a consequence, Baumeister (2016) recently reviewed the current evidence for 'Ego depletion' and concluded that it is still not clear whether self-control resources can reach their 'limit' and suggested that a significant amount of resources may be conserved after self-control actions (Baumeister, 2016).

Self-control strength is required any time an individual controls their thoughts, feelings and behaviour with the aim of achieving a personal goal or following a rule (Muraven, Collins, Shiffman, & Paty, 2005). For instance, effortful self-regulatory processes such as planning, making decisions, controlling responses in tempting situations and monitoring, all deplete self-control resources and this depletion facilitates the enactment of habitual actions (Baumeister, 2016). This model has been applied to a range of behaviours and health problems, including weight control and dieting (Crescioni et al., 2011; Hofmann, Adriaanse, Vohs, & Baumeister, 2014). Despite the relevance of this theory for understanding the underlying abilities of self-regulation and self-regulatory failure, the model has some trouble explaining how and why some people achieve successful self-regulation. Baumeister and colleagues suggest that self-control may resemble a muscle, as it may be weakened by exertion in the short-term. However, some evidence also suggests that regular practice may increase the ability for self-control over the longer-term, resulting in less vulnerability to ego depletion (Baumeister et al., 2006).

1.3.2.4 Health Action Process Approach

The Health Action Process Approach (HAPA) proposed by R. Schwarzer (2008) was designed to explain and understand the self-regulation process as it specifically relates to health behaviours. This model addresses aspects of self-regulation not covered by the previous models, such as how people determine their plans to achieve their intentions and strategies to deal with barriers along the way. The HAPA proposes a distinction between pre-intentional and post-intentional processes. According to this model, self-regulatory skills are required in the post-volitional stage to achieve the intended health behaviour. The self-regulatory processes involved in this stage have three phases: planning; action control and maintenance (see Figure 1.4). Planning is the process of transforming the intention into detailed instructions (action plans) of how to perform the action. Once the action is initiated it is controlled by cognitions and in order to be maintained it requires persistence as well as strategies (coping plans) to overcome obstacles and difficulties. This model also suggests that perceived self-efficacy influences all stages of the behaviour-change process. There is evidence for the validity of this model for a range of behaviours, such as physical activity, dieting, dental flossing and seat belt use (Lhakhang, Godinho, Knoll, & Schwarzer, 2014; Schwarzer et al., 2007). However, it does not provide an explanation of the resources required for the volitional processes nor it does it cover all the processes suggested by the previous models, for example self-monitoring.

Figure 1.4 The HAPA model



Source= Schwarzer (2008)

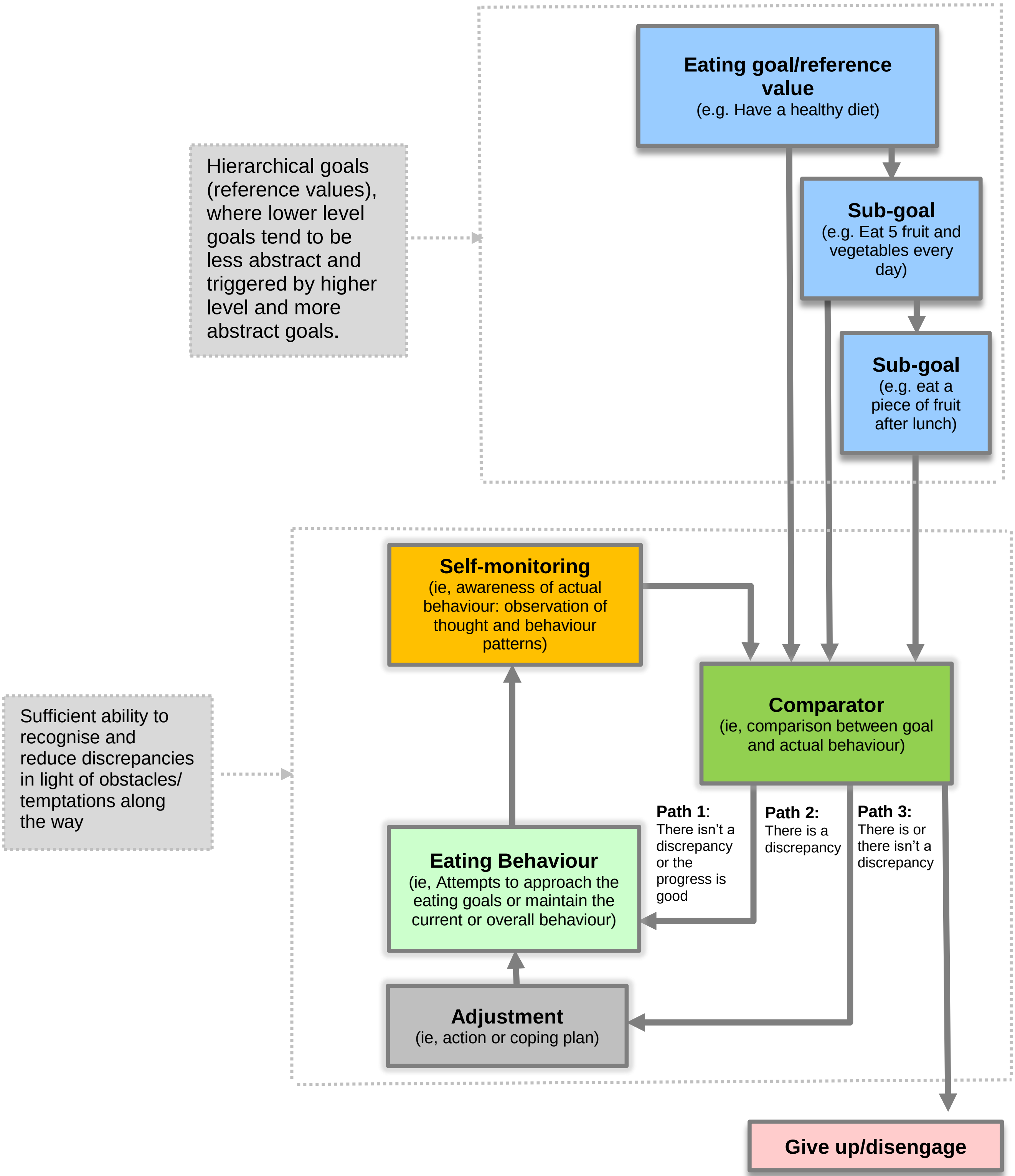
1.3.2.5 Proposed model of self-regulation of eating behaviour

Although there are differences in the theoretical approaches proposed for self-regulation in the above models, they all explain self-regulation as a process required to translate intentions into actions, where an individual's goal is seen as a reference point. Taking into account the contribution of each of these theories, self-regulation may involve processes of self-monitoring; appraising progress and making adjustments to reduce discrepancies (action and coping plans) when necessary. It may also involve the ability to control thoughts, attention, behaviour and emotion to overcome barriers and temptations along the way.

However, none of the established models presented above include all of these processes and skills and they were not specifically designed for understanding the self-regulation of eating behaviour. Considering this, a model of self-regulation of eating behaviour is proposed and schematised in Figure 1.5 and this model is used within this thesis as a reference for understanding the components and abilities involved in the process of eating self-regulation. This model adapts the existing models of self-regulation to the context of eating behaviours and also provides some coherence between the theories. The proposed model was developed mainly based on the feedback loop model of self-regulation by Carver & Scheier (2001), but it also includes other components highlighted by other models such as action and coping plans (Schwarzer, 2008) and the underlying skills involved in the process of self-regulation (Baumeister, 2016). This proposed model represents only the processes and skills for self-regulation, and therefore it does not include influential factors such as motivation and self-efficacy.

The proposed model creates a sense of the main components and skills involved in the process of self-regulation of eating behaviour. It was built on the proposition that self-regulation is neither completely automatic nor completely reflective, and can operate through both of these processes (Forster & Jostmann, 2012; Presseau et al., 2014). Reflective processes require effortful behaviours and conscious deliberation, and decision making (Presseau et al., 2014). On the other hand, automatic processes require less cognitive ability to operate and increase efficiency of goal-directed behaviours, allowing individuals to perform multiple tasks (Forster & Jostmann, 2012). Bargh and Williams (2006) have reasoned that self-regulatory actions are more conscious at the beginning and become more automatic and effective over time. Therefore, the proposed model for the self-regulation of eating behaviour is presented as a continual reflective and/or automatic and multi-level process of self-monitoring; appraising progress and attempting to approach or maintain the desired eating goal; making adjustments to it when necessary or giving up. These processes and abilities in the self-regulation of eating behaviour are discussed in the next sections.

Figure 1.5 Schematisation of the proposed process for self-regulation of eating behaviour



Note= Each colour represents one component of the self-regulation process.

1.3.3 Self-regulatory processes

According to the proposed model the processes involved during the self-regulation of eating behaviours are setting goals, self-monitoring, appraising progress, self-adjustment; persistence and disengagement. These processes are discussed below.

Eating goals in the proposed model are a prerequisite and serve as a reference value that energizes and directs the process of self-regulation of eating behaviours. As healthy dietary behaviours are complex behaviours (Aarts & Custers, 2009), the proposed model follows the suggestion that these goals can be ordered hierarchically and differ in their levels of abstraction (Carver & Scheier, 2001; Rasmussen et al., 2006). Healthy eating goals are usually more concrete at the lower level and tend to be directly related to the individual acts (target behaviours). Lower level and concrete goals may also be seen as plans or strategies (Carver & Scheier, 2001). Concrete goals when well learned and consistently repeated, may be triggered automatically without awareness (Aarts & Custers, 2009). Higher-order goals may serve as a reference point to lower level goals. Although each goal has its own feedback loop system, moving toward achieving a lower level goal contributes to achieving a higher level and more abstract goal (Michie, Ashford, et al., 2011; Rasmussen et al., 2006). To put it differently, the output (eating behaviour) of higher-order goals is the overall output of the lower-order goals. For instance, eating five fruit and vegetables a day (lower level goal) would help to be healthier (higher level goal). Higher-order goals related to the sense of self and identity may very often be essential to helping individuals achieve long lasting goals, as they are a very important source of wants and needs, giving stability to behaviour patterns (Michie & West, 2013). The function of this hierarchy may be more effortful and conscious when a new behaviour is being learned and more automatic in its maintenance (Carver & Scheier, 2001).

The ***Self-monitoring*** component in the proposed model refers to the process of observing thought patterns, emotional reactions and behaviour, and the conditions under which these reactions occur. It refers to the 'input' component in the Carver and Scheier model. It can involve both effortful actions of keeping a record of the target behaviour (Michie, Ashford, et al., 2011) or an automatic awareness of the actual behaviour. Self-monitoring allows people to have a clear idea about their own performance which may lead to effective goal pursuit (Bandura, 1991). However, self-monitoring, in itself, has little influence on self-directed actions.

The ***Comparator*** component in the proposed model is a fundamental function that guides people’s actions. It evaluates the self-observed information (input) against personal standards (goals) (Bandura, 1991), which yields two possible outcomes: there is a discrepancy between behaviour and goal or there is not (Carver & Scheier, 2001). Identifying patterns through self-monitoring can give people insights into what leads them to behave in certain ways and what can be done to correct or maintain their behaviour (Bandura, 1991, 2005). The evaluation process enables people to use adaptive control rather than just being reactive to the result of their efforts (Bandura, 1991). Therefore, the process of self-monitoring and appraising progress is not just a mechanical tracking and registry process of one’s performance and progress, as it involves decision making and problem solving, giving the direction for our behaviour. This process may be reflective at the beginning, when an individual is pursuing new target behaviours, but with time these skills become more automatic, although the behaviour may still rely on this mechanism (Aarts & Custers, 2009). The efficiency of this process will be directly related to the ability to detect discrepancies, even when they represent minor deviations (Carver & Scheier, 2001).

When no discrepancy is noted, no changes to eating behaviour (output) is required, and the behaviour remains the same (**Path 1**). However, when a discrepancy between the behaviour and the eating goal is observed, people may interrupt their efforts to assess the likelihood of a successful outcome (Carver & Scheier, 2001) and three possible pathways may be chosen; **Path 1:** people may ***persist*** with working toward their eating goal as they note progress, even though there is still a discrepancy between goal and behaviour (or outcome, in the case of weight loss); **Path 2:** make ***Adjustments*** to their behaviour, by making new action or coping plans – that is, making changes to the more concrete goals that are part of the goal chain to achieve the more abstract goal (i.e. have a healthy diet); or **Path 3: *Disengage*** from further efforts or potentially disengage from the eating goal itself.

Therefore, people may choose to persist with working on their plans (**path 1**). In situations where the higher-order goal is for example ‘lose weight’, it may take some time until the dietary plans show an effect on weight, and persisting with working on a plan may help people achieve their goal in the long-term as it becomes more habitual (Lally & Gardner, 2013). As habits are formed and are in line with individual’s goals, self-regulatory actions require less resources to be enacted, become more automatic and less susceptible to failure (see section 1.3.4).

Alternatively, people may make adjustments to their goals (**path 2**). The hierarchical approach of this proposed model allows people to shift the way they are trying to achieve a higher level goal, by amending or changing completely lower level goals. Making specific concrete plans, including where, when and how the action will be performed (Gollwitzer & Oettingen, 2011) has been related to increased likelihood of successful self-regulation of eating behaviour (Stubbs & Lavin, 2013; Veling, Aarts, & Stroebe, 2013).

On the other hand, unwanted habits are usually difficult to change (Michie & West, 2013) and may lead to self-regulatory failure and disengagement from further efforts (**path 3**). Self-regulatory failure may also be influenced by other factors, such as lack of motivation and high expectations (Kwasnicka, Dombrowski, White, & Sniehotta, 2016; Rasmussen et al., 2006), as discussed in section 1.3.5. It is important to note that even when there is no discrepancy, people may still choose to disengage from their goal, due to a lack of motivation. Development of coping strategies[5] (**path 2**) for anticipated obstacles may be an alternative approach to dealing with these difficult situations (Sniehotta et al., 2005). It has been suggested that the best way to avoid an unwanted behaviour is by approaching something else (Rasmussen et al., 2006). According to Sniehotta et al. (2005) experience is also a prerequisite for effective

[5]Coping plan refers to the mental link between the anticipated obstacle and the behavioural response (Sniehotta, Schwarzer, Scholz, & Schuz, 2005)

coping strategies. Self-observed information about the social and environmental impediments and facilitators may help people to plan how to overcome barriers and set effective strategies to achieve their goals (Bandura, 2005). As the process becomes more effective, behaviours are adjusted in an automatic and ongoing manner, where one action forms the input for the next action, allowing for constant adjustments and efficient pursuit of the goal (Papies & Aarts, 2011).

These self-regulatory processes (setting goals, self-monitoring, appraising progress, self-adjustment and persistence), require sufficient cognitive resources to successfully self-monitor and evaluate eating behaviour and reduce discrepancies between goals and behaviour in light of obstacles and temptations along the way (Hofmann, Schmeichel, et al., 2012). The next section discusses how the ability to exert control over thoughts, feelings, attention, behaviour and the environment may underlie these processes of self-regulation (Hofmann, Schmeichel, et al., 2012; Michie, Ashford, et al., 2011).

1.3.4 Underlying self-regulatory ability

Many authors argue that executive function underlies effective self-regulation (Barkley, 2001; Blair & Ursache, 2011; Hofmann, Schmeichel, & Baddeley, 2012). Executive function is defined as the cognitive abilities required for action planning, strategy development, flexible behaviour, maintenance of behaviour and resistance of interferences (Barkley, 2001; Blair & Ursache, 2011). In order to understand the relationship between executive function and self-regulation, Hofmann, Schmeichel, et al. (2012) suggested clustering the main executive actions into three facets: working memory operations, mental shifting and behavioural inhibition.

Working memory is the ability to maintain and update relevant mental representations of goals or strategies and shield this information from distraction. It is relevant for the regulation of thoughts and attention (Hofmann, Schmeichel, et al., 2012). Papies and Aarts (2011) argue that working memory ability plays an important role in most self-regulatory processes (Papies & Aarts, 2011). Individuals who are able to control mental representations of various behavioural options and associated outcomes are more likely to persist in working on a difficult task (Fujita, 2011). Suppressing unhelpful and interfering thoughts and directing attention to goal relevant information may help to shield self-regulatory goals from competing goals in tempting situations (Hofmann, Friese, Schmeichel, & Baddeley, 2011), and this seems to happen outside awareness (Forster & Jostmann, 2012).

The second facet, mental shifting, is the ability to adjust personal goals and action plans to changing circumstances (Hofmann et al., 2011). It supports a more flexible self-regulatory goal pursuit. The task-switching ability helps people to disengage from unhelpful strategies and pursue alternative means to reach the same goal (Hofmann, Schmeichel, et al., 2012). Being able to disengage from unattainable goals, followed by a reengagement in an alternative goal is an essential ability in self-regulation of behaviour (Rasmussen et al., 2006). Task-switching supports adaptive adjustment, and may be the key to success in dietary restraint, as discussed earlier in section 1.2.

Finally, behavioural inhibition, refers to people's ability to actively inhibit behaviour and impulses that do not conform to their standards (Baumeister, Gailliot, DeWall, & Oaten, 2006; Hofmann, Baumeister, Forster, & Vohs, 2012). Impulses are commonly seen as any thought, feeling, attention or behaviour that when activated may promote the tempted behaviour (Fujita, 2011). Dealing with temptations (e.g. not eating a cake) that stand in the way of higher-order goals (e.g. losing weight) requires self-control (Forster & Jostmann, 2012). Being able to exert control over the behaviour, that is – resolve the conflict in favour of the higher-order goal, is a fundamental skill for successful self-regulation (Hofmann, Schmeichel, et al., 2012). The goal shielding explained previously seems to help goal conflict and promote effective behavioural inhibition actions (Forster & Jostmann, 2012).

The Strength Model of self-regulation, described above in section 1.3.2.3, suggests that executive functions rely on limited resources (Baumeister et al., 2006; Hofmann, Schmeichel, et al., 2012; Muraven & Baumeister, 2000). Laboratory studies exploring self-regulatory failure of eating behaviours support this theory (Baumeister et al., 1998; Baumeister et al., 2007; Muraven, Tice, & Baumeister, 1998). For example, in one experiment the intervention group was instructed to resist the urge to eat cookies, while the two control groups did not have to apply self-control. Participants from the intervention group performed worse in the subsequent task requiring self-control than those from the control groups (Baumeister et al., 1998). This indicates that self-regulatory resources become temporarily depleted by the exertion of self-control (Baumeister et al., 2007). However, evidence from the literature has also suggested that there are circumstances in which ego depletion does not happen. For example, ego depletion is less likely to occur when the control processes required in the first and second attempt of self-control are similar (Dewitte, Bruyneel, & Geyskens, 2009). Besides, applying self-control over time may lead to better self-regulation (Baumeister, 2016; Converse & DeShon, 2009). These skills can become more effective through training, which would increase resistance to self-regulatory failure (Baumeister et al., 2006; Hofmann, Schmeichel, et al., 2012). Indeed, higher self-control strength has been related to greater ability to successfully regulate behaviour (Tangney, Baumeister, & Boone, 2004). Therefore, training in self-regulatory skills could reduce the need for cognitive resources and increase the ability to overcome barriers as the behaviour would become more automatic (Gollwitzer & Sheeran, 2006; Rothman, Baldwin, Hertel, & Fuglestad, 2011).

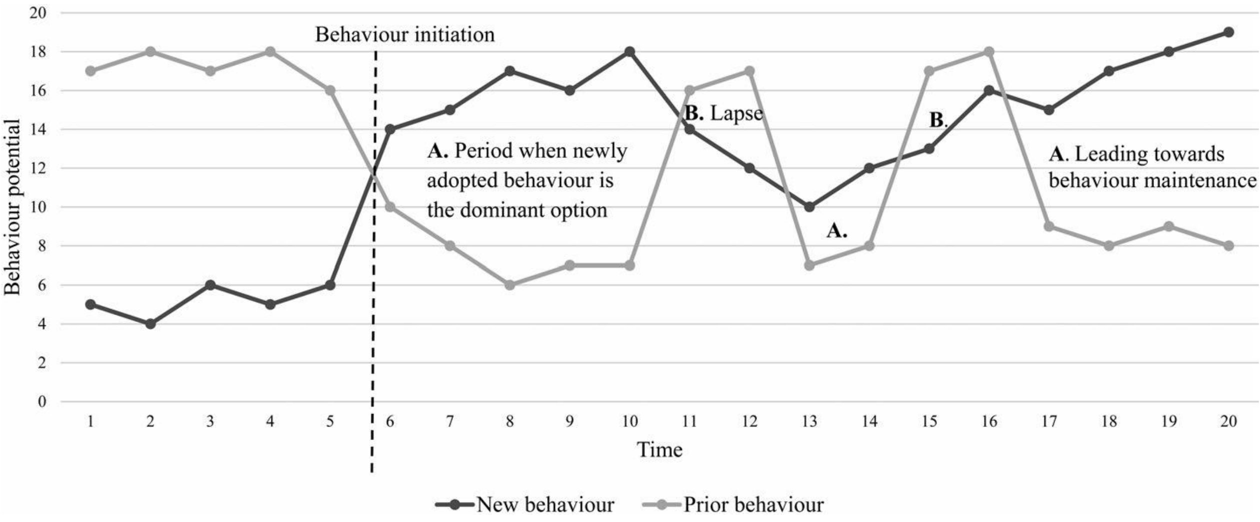
In sum, a variety of cognitive abilities underpin self-regulatory actions. Although the ability to exert control over thoughts, attention and behaviour depends on limited resources and is subject to depletion, once routinized it may become more effective and automatic (Forster & Jostmann, 2012). However according to the model developed for this thesis, more automatic skills would still rely on cognitive resources, as self-regulatory actions are in most cases a combination of automatic and reflective actions that work in concert. In agreement with this, Forster and Jostmann (2012) have highlighted that the extent to which a self-regulation action can be called conscious or non-conscious, as well as the amount of effort required in each of these process, is still not clear and should be explored in further research studies.

1.3.5 Successful self-regulation

Successful self-regulation happens when a goal (e.g. have a healthy diet or lose weight) is translated into behaviour (goal attainment). As discussed in the previous sections, the ability to regulate eating behaviours in the presence of obstacles and temptations seems to be a fundamental individual skill that helps people to achieve their eating goals. However, the lifestyle changes needed for intentional weight loss and dietary change are usually difficult to achieve and to maintain (Curioni & Lourenco, 2005). Other individual and contextual influences can also bring about changes in dietary behaviours and weight (Kwasnicka et al., 2016; Michie & Atkins, 2013). The COM-B model, which states that Capacity, Opportunity and Motivation are all necessary conditions for any behaviour to happen, suggests that self-regulation is only one of the psycological capaciticies relevant for behaviour change, while other capacities, as well as motivational and contextual factors may also play a role (Michie & West, 2013).

In line with this, a systematic review exploring the theories on the maintenance of behaviour change suggested that the importance of self-regulatory skills varies over the course of the behaviour change process, which may be influenced by other individual and contextual factors (Kwasnicka et al., 2016). This review illustrated the likelihood of engaging in an intended behaviour (behavioural potential), concluding that initiation of the intended behaviour is likely to happen when motivation is high and opportunity costs are low (Figure 1.6). The need for effective self-regulatory skills increases as the motivation decreases and costs increase. Lapses may happen over the course of behaviour change mainly due to ego depletion, but their frequency reduces as the behaviour becomes more habitual. Social and environmental contexts may influence in a positive or negative way the maintenance of the intended behaviour, and self-regulatory skills are required to prevent the loss of healthy habits when environmental cues change.

Figure 1.6 Changes in behavioural potential following the initiation of the target behaviour



Source= Kwasnicka et al. (2016)

1.3.5.1 Other individual and contextual influences

It has become clear from the previous sections that reflective (i.e. plans, intention and beliefs) or automatic (i.e. motives, desires and habits) motivational factors are important for successful self-regulation since they energise and direct behaviour (Michie & West, 2013). According to the PRIME theory, intentions and plans only direct people's actions when they generate stronger wants (arising from feelings of anticipated pleasure or satisfaction) and needs (arising from anticipated relief from discomfort) than competing goals at a relevant moment. Stronger 'bad' habits may push people off the path they have chosen even when they have strong intentions and self-regulatory skills (Michie & West, 2013). On the other hand, stronger 'good' habits help goal attainment (Gardner, 2015; Lally & Gardner, 2013). This means that successful self-regulation relies heavily on habits (Aarts & Dijksterhuis, 2000).

Increased expectancy of self-regulatory success (self-efficacy) and value of and commitment to higher-order goals are critical motivational factors that may also increase the likelihood of successful self-regulation (Fishbach, Friedman, &

Kruglanski, 2003). It is suggested that these motivational factors help people to resolve goal conflicts and regulate their behaviour in tempting situations, even when goals are more abstract and distant, such as losing weight (Fishbach et al., 2003). On the other hand, too high expectancy, adversity, distress emotions, and doubt may decrease the likelihood of successful self-regulation (Carver & Scheier, 2001; Rasmussen et al., 2006).

Other capacities, such as knowledge, can interact with self-regulatory skills to influence successful self-regulation. If people do not know how to go about reaching their goals, such as achieving a healthy diet or losing weight, self-regulation falls apart (Carver & Scheier, 2001). Therefore, high self-regulatory skills may be pointless if people do not know what a healthy diet consists of and what they should do to lose weight in order to establish concrete goals to reach them. Since the strategies people choose to achieve a goal vary from person to person (Carver & Scheier, 2001), nutrition knowledge may play a role in people's capacity to successfully self-regulate healthy eating behaviours. The opposite might also be expected to hold true, as people with high nutrition knowledge, but that lack self-regulatory skills, may also be less successful at achieving a healthy lifestyle (Kliemann, Wardle, Johnson, & Croker, 2015).

Additionally, a favourable social and physical environment may also help people to achieve their goal, decreasing the need for effortful self-regulation, for example by ensuring that healthy foods are available and easy accessible (Michie & Atkins, 2013). However, as discussed in section 1.1, people may differ in the need for self-regulatory skills to deal with the obesogenic food environment due to differences in their genetic predisposition to the food environment (Llewellyn & Wardle, 2015). For some people the food environment may have a stronger influence on their eating behaviours than for others. This suggests that people with a lower genetic risk of weight gain would require less self-regulatory skills to successfully control their weight and diet in the current food environment compared to those with a higher risk.

1.4 Summary

The evidence presented in this chapter indicates that changes in dietary and physical activity patterns, attributable to environmental factors, have been promoting positive energy balance. However, these changes do not affect all people similarly and recent studies have suggested that the ability to self-regulate eating behaviour may help people to cope with the obesogenic environment and achieve, as well as maintain a healthy weight and diet. Therefore, promoting eating self-regulatory skills could be a promising approach for the prevention and treatment of obesity. Eating self-regulatory skills refer to the individual’s ability to manage their eating behaviour and override their natural impulses towards tempting foods to achieve and maintain a healthy diet and weight. Although the impact of eating self-regulatory skills on healthy dietary behaviour and weight control may be influenced by other individual and contextual factors, understanding their independent role in helping people to achieve and maintain a healthy diet and weight could be informative for the development of more effective interventions. Also, due to the considerable debate over whether self-regulation resources are limited (De Ridder et al., 2012), there is a clear need to investigate whether self-regulatory skills can be improved through training. Understanding if these skills can be enhanced using public health interventions and the impact of increases in eating self-regulatory skills on dietary behaviours and weight control may also contribute to the development of more effective interventions.

CHAPTER 2. EVIDENCE RELATING EATING SELF-REGULATORY SKILLS TO HEALTHY DIETARY BEHAVIOURS AND WEIGHT CONTROL: A SCOPING REVIEW

This chapter describes the current evidence from observational and intervention studies for the relationships between eating self-regulatory skills, dietary behaviours and weight control in the general adult population. It has been argued that there is a lack of interventions seeking to establish the most effective way to promote eating self-regulatory skills (Boekaerts et al., 2005; Johnson et al., 2012). Therefore, this chapter also aims to provide evidence for 1) the effect of weight loss and dietary interventions on self-regulatory skills and; 2) the impact of changes in self-regulation on intervention effectiveness.

A scoping review was conducted to explore the literature on whether 1) eating self-regulatory skills are related to healthy dietary behaviours and weight control; 2) eating self-regulatory skills can be improved through practice; and 3) enhancing eating self-regulatory skills impacts on dietary behaviour changes and weight loss. This chapter is organised as follows. First the methods of the scoping review are presented, this includes describing the inclusion and exclusion criteria, the search strategy and the data extraction and synthesis. The evidence from observational and intervention studies is then presented and discussed. The chapter concludes with a summary of the main results, the limitations and gaps found in the literature.

2.1 Scoping review methodology

This scoping review followed the methodological framework proposed by Arksey and O'Malley (2005), which was complemented by Levac, Colquhoun, and O'Brien (2010). The scoping study is a technique that ‘maps’ the relevant literature in a specific field. This type of review tends to address more broad questions and or topics. It allows researchers the investigate the extent, range and nature of research in a specific area and identify research gaps in the literature (Arksey & O'Malley, 2005). A scoping review is usually recommended when the area of research is complex and has not been reviewed comprehensively before. It is considered a rigorous and transparent method for mapping a topic of research (Arksey & O'Malley, 2005).

2.1.1 Inclusion and exclusion criteria

2.1.1.1 Measures of self-regulatory skills

Only studies that used a valid and reliable measure of self-regulation were included. A number of laboratory and psychometric tests have been developed to assess self-regulatory skills. However, there is a lack of consensus around whether self-report scales and laboratory tasks assess the same processes and which yields the best validity for assessing self-regulation. A meta-analysis of the convergent validity of self-control measures concluded that there is a very low correlation between self-report and laboratory tasks of self-control (Duckworth & Kern, 2011). Although laboratory tasks allow the assessment of objective performance of self-control, results from the meta-analysis showed substantial heterogeneity on the convergence between these measures suggesting random task-specific variance, while self-report questionnaires presented a greater convergence. These results suggest that laboratory and self-report measures might not assess the same cognitive processes. In addition, studies measuring self-regulation in large sample sizes typically opt for self-report measures, as these are economical and easily administered and analysed, although they rely on participants' memory. As this thesis aims to investigate self-regulatory skills in the general adult population and to allow comparison between studies from the literature, only research studies assessing self-regulation using self-report psychometric measures were included in this review. Both general and eating-specific psychometric measures of self-regulation were accepted.

2.1.1.2 Dietary intake and weight measurement

Studies using either self-report measures or objective measures of dietary intake and weight status were included.

2.1.1.3 Population

This review was also limited to studies conducted with samples representing the general population. Studies focusing on specific and illness-related populations, such as people with diabetes or eating disorders, were excluded since other aspects related to their condition may influence the relationships between self-regulatory skills, dietary behaviours and weight control.

2.1.1.4 Age group

The focus of the review was on studies conducted with the adult population. However, as there is an overlap between what is considered older adolescents and young adults in different studies, the review also includes studies exploring self-regulatory skills in both of these populations.

2.1.1.5 Type of studies

Both observational and intervention studies assessing self-regulatory skills were included. Although there has been considerable interest in using self-regulatory training within weight management and dietary interventions as it has been linked to better outcomes (Kelly et al., 2013; Kirk et al., 2012; Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Stubbs & Lavin, 2013), the majority of these studies have not evaluated the effect of the intervention on self-regulatory skills. As a consequence, it is neither possible to state whether there was an improvement in eating self-regulatory skills nor how much self-regulatory skills have contributed to the interventions effectiveness. For that reason, only intervention studies assessing self-regulatory skills using self-report measures were included.

2.1.2 Search strategy

The identification of relevant literature in scoping studies should be as comprehensive as possible. An electronic search of four databases (Web of Science; Pubmed; Scopus and PsycInfo) was undertaken in May 2017. The search terms used in these databases are provided in Appendix 2.1. However, research evidence was also identified via other sources, such as: reference lists, hand-searching of relevant journals, existing networks, and relevant conferences. Only studies published in the previous 10 years (from 2007 onwards) and those that were published in English were included, due to time, cost and practical reasons. Since scoping reviews do not have a very specific question, the discussion and synthesis of the evidence could be potentially unfeasible if the time range allowed was wider. It is worth mentioning that relevant papers may have been missed because of these limitations. I applied the exclusion and inclusion criteria to all citations looking at the title, abstract and methods. Full articles were obtained for all papers that appeared to meet the criteria.

As a result, a total of 2194 studies were initially identified. After removing duplication 1959 studies underwent the screening process. A total of 45 studies were considered eligible to be included in this scoping review, of these 27 were observational and 18 were interventions.

2.1.3 Charting the data

Tables were produced containing the following information about the included studies: author and year of publication; study design; sample; procedure/intervention details; self-regulation measure; diet and weight measures; and key results. Data from observational and intervention studies are presented separately. The results are summarised by themes related to the research questions. Potential limitations of the studies included are also discussed. However, it is worth mentioning that this review did not attempt to present the 'weight of evidence', since this kind of review does not seek to assess the quality of evidence, in contrast to systematic reviews.

2.2 Evidence from observational studies

The search resulted in 15 cross-sectional studies and 12 longitudinal studies being identified (see Table 2.1). These are discussed below in relation to the first research question which was whether self-regulatory skills are related to diet and to weight.

Table 2.1 Evidence from observational studies for the relationships between self-regulation, weight control and healthy diet

First author (year), country	Design	Sample	Procedure	Self-regulation measure	Diet and weight measures	Relevant findings
Allan et al. (2011), UK	LG	50 undergraduate students; 62% female	Students from one university in the UK were invited to participate. At baseline participants reported their eating intentions and self-reported their executive control. Over the following 3 days, they reported their actual food consumption.	Dysexecutive Questionnaire - DEX (20 items)	Computerised EFD were used. Intention-behaviour gap was calculated for F&V and snacks, by subtracting the intended for the actual number of portion consumed.	Executive function explained 17% of the variance on the intended-behaviour gap for F&V (*p*<.001) and 23% of the variance of the intended-behaviour for snacking intake (*p*<.01). Eating less F&V and more energy dense snacks than intended was related to weaker executive function.
Allan et al. (2013), UK	LG	72 university students; 83% female	University students completed measures of intention, action planning and planning skills at baseline. One week later, they completed the snacking behaviour questions.	4 items measured action planning specifically related to snacking intake.	3 items measured snacking behaviour on a four-point Likert scale from strongly agree to strongly disagree.	Action planning did not predict snacking behaviours over a week, and only predicted lower snacking behaviours when it was interacted with planning skills measured using the 'Zoo Map' task (*p*=.05).
Anderson-Bill, Winett, and Wojcik (2011), USA	CS	963 adults; 83% female; M age=44.4 yo	Interested participants were directed to a web-based health intervention (WB-GTH site), where they were screened and those eligible that gave informed consent, completed the baseline online questionnaire.	32 items assessed self-regulation (planning, tracking and strategies for healthy eating)	FFQ assessed fat, fiber, fruits and vegetable intake	Enactment of self-regulatory behaviors was a moderate predictor of Web-health users' fat intake and a strong predictor of fiber, fruits, and vegetable consumption
Benard et al. (2017), France	CS	51,043 adults; 23% male; 62% normal weight	This study was conducted as part of the NutriNet-Santé study, a large ongoing web-based prospective cohort started in France in May 2009.	Barrat Impulsiveness Scale - BIS-11 (30 items) by Patton et al (1995). It assesses three aspects of impulsivity: Motor, attentional and non-planning.	Weight and height were self-reported.	Individuals with high impulsivity trait were more likely to be obese (OR=1.8 for men and OR=1.3 for women)
De Vet et al. (2014), Netherlands	CS	11,392 European adolescents; 10 to 17 yo; 50% girls; 75% had a normal weight	Students were recruited from nine different European countries (including the UK). Schools represented rural and urban regions as well as high and low SES areas. The survey was completed in classroom setting.	Tempest Self-Regulation Questionnaire for Eating (24 items) developed and validated in this study.	FFQ measured daily intake of sugar-sweetened beverages and snacks, F&Vs.	Eating self-regulatory competence was related to lower snacking intake (r=-.36) and soft drink intake (r=-.25) and to higher fruit (r=.30) and vegetable (r=.21) intake.
Evans, Norman, and Webb (2017), UK	LG	**Sample 1**: 133 adults; M age=23 yo; 68% female **Sample 2**: 125 adults; M age=23 yo; 72% female	Interested participants from an university were randomised to answer online questionnaires on F&V intake (Sample 1) or on unhealthy snacks (Sample 2) intake. Both questionnaires collected data on dietary intake and self-control at baseline. One week later participants reported their dietary intake again.	Brief Self-Control Scale (13 items) by Tangney et al (2004)	Questions on how many portions of F&V they ate in the past week and how many times they ate unhealthy snacks per day	F&V intake at follow-up was not related to self-control (r=0.12, p>.05). However, self-control was inversely related to unhealthy snacks (r=-.32, p<.01)

Table 2.1 Continue

First author (year), country	Design	Sample	Procedure	Self-regulation measure	Diet and weight measures	Relevant findings
Gellert et al. (2012), Germany	LG	909 adults; 81% female; 16 to 78 yo; 73% had an university degree	Participants completed an online survey at baseline **(T1)** and 4 months later **(T2)**. Planning, intention and future time perspective were only measured at **T1**, while F&V intake was measured at T1 and T2.	2 items measured action planning and coping planning.	FFQ measured F&V intake.	F&V at T2 was related to planning (r=.40). The effect of planning on F&V intake was stronger for people with a more limited future time perspective.
Godinho et al. (2014), Germany	LG	203 university student; 85% female, M age=22.2	Participants were recruited from three universities and were requested to complete online assessments at baseline **(T1)**, 1 week **(T2)**, and 2 weeks later **(T3)**. Intention was assessed at **T1**; F&V intake was assessed at **T1** and **T3**; Action planning was assessed at **T2** and action planning was assessed at **T3**.	3 items measured coping planning and 3 items measured action control. All items were related to F&V intake.	FFQ measured F&V intake.	It was found a slight decrease in F&V intake over 2 weeks (2.59 vs 2.43 servings/day). The effect of intention on F&V intake at 2-week follow-up (T3) was mediated by planning (p=.04). F&V intake at T3 was correlated to both action control (r=.42) and coping planning (r=.36).
Hankonen et al. (2014), Finland	LG	854 male military conscripts	Participants completed questionnaires on trait self-control and social cognitive factors (e.g. planning) upon entering the service and a FFQ after 8 weeks.	Shortened Self-Control Scale (20 items) by Tangney et al (2004)	FFQ measure dietary intake. Two indexes were calculated: F&V intake index and fast food index.	High baseline self-control was associated with higher F&V intake (r=.21) and lower fast food intake (r=-.19) at 8-week follow-up. Planning mediated the relationship between self-control and F&V intake.
Junger et al. (2010), Netherlands	CS	201 adolescents; 52% female; M age=16.8; 15 to 20 yo; M BMI=21.1 kg/m^2	Students were randomly chosen from 8 schools located in 7 different cities in Netherlands. Questionnaires were completed on a computer during school time.	Brief Self-Control Scale (13 items) by Tangney et al (2004)	FFQ measured F&V, unhealthy foods and breakfast intake. BMI was calculated based on self-report weight and height.	Self-control was positively related to breakfast intake (β=.24, *p*<.001) and negatively related to BMI (β=-.17, *p*<.05), but no relationships between self-control and F&V and unhealthy snacks intake were found.
Kalavana et al. (2010), Cyprus	CS	473 adolescents; 58% female; M age=16.6	6 schools were randomly chosen. Students completed the questionnaires under supervision of researchers. Only students who had an eating goal were included. Taking part in the study was voluntary.	The following subscales of the Self-Regulation Skills Battery by Maes et al (2005): Goal commitment (5 items); Goal efficacy (4 items) and Goal ownership (4 items).	A FFQ adapted for Mediterranean diet. A total score for healthy foods and unhealthy foods were created.	All self-regulatory skills subscales were positively related to healthy eating (r=.12 to .20) and negatively related to unhealthy eating behaviours (r=-.10 to -.13). Goal ownership and goal efficacy were predictors of a healthy diet, while only goal efficacy was a predictor of an unhealthy diet (*p*<.001).
Kakoschke et al. (2015), Australia	CS	146 undergraduate women; M age=20.0; M BMI=22.9 kg/m^2	The study took place in a food laboratory. Questionnaires were completed after the taste task.	Barrat Impulsiveness Scale - BIS-11 (30 items) by Patton et al (1995): Motor, attentional and non-planning impulsivity	Sweet and salty snacks were measured using a so-called taste test. The amount of each food consumed was calculated in kilojoules.	Motor and attentional impulsivity had a small but positively correlation with sweet and savory intake (r=.16 to .19), while non-planning was not related to any of the dietary outcomes.

Table 2.1 Continue

First author (year), country	Design	Sample	Procedure	Self-regulation measure	Diet and weight measures	Relevant findings
Keller et al. (2015), Switzerland	CS	616 adults; 51% female; M age=44	Online survey conducted with people resident in the German-speaking region of Switzerland.	Weight Management Strategies Inventory - WMSI (63 items), developed and validated in this study.	BMI was calculated based on self-report weight and height.	Inhibition and attention control strategies were related to higher BMI.
Kinnunen et al. (2012), Finland	CS	482 adult male conscripts; M age=20	Questionnaires were answered in a class-room setting of the Finnish National Defence. Taking part in the study was voluntary.	Shortened Self-Control Scale (20 items) by Tangney et al (2004)	BMI was calculated based on objectively measured weight and height.	There was a weak and inverse correlation between SCS and BMI (r=-.15).
Meule et al. (2012), Germany	CS	480 adults; 20.4% male; M BMI=23 kg/m^2	Online survey conducted with students from diverse German Universities.	Perceived Self-regulatory Success in Dieting Scale (3 items) by Fishbach et al. (2003).	BMI was calculated based on self-report weight and height.	Self-regulation showed a medium and inverse correlation with BMI (r=-.42 to -.44)
Mullah et al. (2014), Australia	LG	154 undergraduate students; 74% female; M age=20.3	Students from one university in Australia were recruited. At baseline participants completed a questionnaire measuring, intention to consume F&V and avoid saturated fat, and impulsivity and temporal orientation. One week after, they completed a self-report measure of eating behaviour.	Barrat Impulsiveness Scale - BIS-11 (30 items) by Patton et al (1995) It assesses three aspects of impulsivity: Motor, attentional and non-planning.	FFQ was used. Daily saturated fat intake and F&V intake were calculated.	Impulsivity was not correlated to F&V intake (r=-.02), only to saturated fat intake (r=.18). After controlling for socio-demographics, impulsivity only predicted higher saturated fat intake at one-week follow-up (*p*<.05).
Nothwehr et al. (2007), USA	CS	407 adults; 58% female; 76% overweight; 22 to 88 yo	Adults (≥18 yo) residents in 2 rural cities in Iowa, US, were invited for this study. Participants attended an appointment at the local church, where they completed the survey questionnaires and were measures and weighed.	Behavioural Objective for Weight Management Scale (43 items) developed and validated in this study.	A FFQ was used. Total calorie and fat intake were calculated. BMI was calculated based on objectively measured weight and height.	The scores for the 9 subscales relating only to eating self-regulation were positively but not significantly correlated to BMI, while all of them were inversely related to calorie intake (r=-.13 to -.33).
Papies et al (2008), Netherlands	CS	52 students; 75% women	The study was conducted in a university laboratory.	Perceived Self-Regulatory Success in Dieting Scale (3 items) by Fishbach et al. (2003)	BMI was calculated based on objectively measured weight and height.	Self-regulation showed a medium and inverse correlation with BMI (r=-.48)

Table 2.1 Continue

First author (year), country	Design	Sample	Procedure	Self-regulation measure	Diet and weight measures	Relevant findings
Price et al. (2017), UK	CS	218 university students; 17% male	Students were recruited from two universities in the UK and answered the questionnaires online.	Brief Self-Control Scale (13 items) by Tangney et al (2004)	BMI was calculated based on self-report weight and height.	Self-control mediated the relationship between future time perspective and BMI. However, self-control showed only a weak correlation with BMI (r=-.15).
Poelman et al. (2014), Netherlands	CS	**Study A** - N=120 adults; 53% male; M age=46.9; M BMI=25.4 kg/m^2 **Study B** - N=278; 15.5% male; M age=46; 66% obese	**Study A** - A random sample of 500 addresses of Dutch individuals were invited to take part and answer the questionnaire by post. **Study B** - Participants were recruited through general practices.	Behavioural Strategies in Weight Management Scale (32 items) was developed in this study.	**Study A** - BMI was calculated based on self-report weight and height. **Study B** - BMI was calculated based on objectively measured weight and height.	**Study A** - As eating behavioural strategies increased, BMI decreased (adjusted β=-.04, *p*<.001) **Study B** - Behavioural strategies were not significantly related to BMI.
Reuter et al. (2010), Germany	LG	853 adults; 77% female; M age=37 yo.	Participants answered the online survey at baseline **(T1)** on predictors and behaviors. 4 weeks later **(T2)**, the same online questionnaire was applied a second time.	1 question on coping planning and 1 question on action planning for F&V intake	FFQ measured F&V intake	Changes in planning predicted changes in F&V intake at 4 weeks follow-up. However, baseline levels of planning did not predict changes in F&V intake.
Schroder et al. (2013), USA	CS	2224 undergraduate students; 42.3% male; M age=20.3	Data was collected between 2007 and 2010 at a university in the US through an online survey. In total it was collected 5 sub-samples.	Habitual self-control questionnaire (14 items) developed and validated in this study.	2 items measured intentional weight loss and weight loss success. Those who had tried to lose 10 or more pounds of body weight were asked to rate the success of their weight loss attempt.	It was found a weak, but positive correlation between successful weight loss (≥10 pounds or 4.5kg) and self-control (r=.22 to .35).
Schwarzer et al. (2007), Germany	LG	700 adults; 73% female; M age=37.7; 50% had university degree	Participants answered the online survey at baseline **(T1)** containing information on risk perception, motivational self-efficacy, outcome expectancies, and behavioural intentions. 4 weeks later **(T2)**, a second online survey was applied containing information on planning, recovery, self-efficacy and eating behaviour.	4 items measured action planning related to dietary intake.	A FFQ measured whether people eat 5 portions of F&Vs every day.	Action planning mediated the relationship between intention and F&V intake at 4-week follow up. People with higher intention to eat 5 servings of F&V and higher action planning, met more frequently the 5 daily portions of F&V 4 weeks later.
Sproesser et al. (2011), Germany	CS	761 adult women; M age=32.5; M BMI=23.6 kg/m^2. 76% had a university diploma	Online survey.	Brief Self-Control Scale (13 items) by Tangney et al (2004)	FFQ measuring 15 food categories, e.g. whole meal products and salty snacks. A food frequency index (dietary quality) was calculated. 4 items measured body weight control motive.	Self-control was positively and weakly correlated with healthier food index (r=.28) but not with weight control motive (r=-.03). However, CFA confirmed that both factors predicted healthy food index (*p*<.001).

Table 2.1 Continue

First author (year), country	Design	Sample	Procedure	Self-regulation measure	Diet and weight measures	Relevant findings
Tomasone et al. (2015), Canada	LG	76 first-year undergraduate students; 79% female; M age=17.8	Students from two first year psychology classes were recruited and completed the baseline survey on self-control, attitudes, subjective norms, perceived behavioural control, and intentions in their first week of class. One week later, they completed a 7-day EFD.	Brief Self-Control Scale (13 items) by Tangney et al (2004)	7-day EFD was used. Average daily F&V intake over one week was calculated.	Self-control was related to F&V intake (r=.24). Self-control predicted higher F&V intake one week later (*p*<.05), but it was not related to a stronger intention to eat F&Vs.
van Osch et al. (2009), Netherlands	LG	**Study 1** - N=572; 53% female; **Study 2** - N=585; 49% female	Participants in **studies 1 & 2** completed an online survey at baseline **(T1)**, one month later **(T2)** and 3-month later **(T3)**. In both studies, self-efficacy and intention were measured in both studies in **T1** and action planning in **T2**. In **study 1** F&V intake was measure at T3 and in **study 2** snacking intake was measure in **T3**.	5 items measured action planning for the dietary outcome.	**Study 1 -** FFQ measured F&V intake. **Study 2** - FFQ measured the consumption of five types of high-caloric snacks.	The findings showed that action planning was a significant predictor of both dietary outcomes (*p*<.001) and mediated the effect of intention and actual behaviour at 3-months follow-up.
Zhou et al. (2015), China	LG	286 university students, M age=23 yo, 73% female	Participants were recruited from one university and were requested to complete assessments at baseline **(T1)**, 2-week follow-up **(T2)**, and 4-week follow-up **(T3)**. Intention was assessed at **T1**; Action planning and action control was assessed at **T2** and F&V intake was assessed at **T1** and **T3**.	3 items measured action control and 3 items measured action planning. All items were related to F&V intake.	FFQ measured F&V intake.	It was found a slight increase in F&V intake over 2 weeks (4.29 vs 4.59 servings/day). The effect of intention on F&V intake at 4-week follow-up (T3) was sequentially mediated by action control and action planning. F&V intake at T3 was correlated to both action control (r=.16) and coping planning (r=.21).

Note= CS: Cross-sectional study. LG: Longitudinal study. M: Mean. BMI: Body Mass Index. FFQ: Food Frequency Questionnaire. EFD: Estimated Food Diary. F&V: Fruit and Vegetables. CFA: Confirmatory Factor Analysis. r= Pearson or Spearman Correlation. yo= years old.

2.2.1 Relationship between eating self-regulatory skills and diet

The majority of the observational studies used a food frequency questionnaire (FFQ) to assess diet, which relies on individual's memory and usually the ability to estimate portion sizes. Self-regulation was assessed using different self-report measures and the most frequently used was the brief Self-Control Scale (SCS) developed and validated by Tangney et al. (2004). A cross-sectional online study using this scale found that self-control was positively and weakly related to healthier food intake (r=0.28) in a sample of 761 adults in Germany (Sproesser, Strohbach, Schupp, & Renner, 2011). The results of this study were limited to women, who had on average a normal weight and were highly educated. However, similar results were found in a sample composed only of adult male conscripts (N=854) in Finland. Hankonen, Kinnunen, Absetz, and Jallinoja (2014) showed that high baseline self-control was weakly and positively related to fruit and vegetable (F&V) intake (r=0.21) and weakly and negatively associated with fast food intake at 8-week follow-up (r=-0.19). Since no baseline data for F&V intake were collected, it was unknown whether self-control was related to an increase, maintenance or decrease in F&V intake over the 8 weeks. In the same vein, Tomasone, Meikle, and Bray (2015) found that self-control was weakly and positively related to F&V intake (r=0.24) one week later in a sample of 76 undergraduate students (76% female) in Canada. However, in this study F&V was measured using an Estimated Food Diary (EFD), which requires people to record prospectively every single food and drink they eat over 7 days and this may potentially lead to dietary alterations (Walton, 2015). But similar to the previous study, it is unknown whether F&V intake changed over 7 days and if this was related to self-control, as no baseline data were collected. This is important since the transition to university increases the risk of unhealthy dietary changes and weight gain (Vella-Zarb & Elgar, 2009).

Junger and van Kampen (2010) have also used the SCS to investigate the relationship between self-control and dietary behaviours in a cross-sectional sample of 201 adolescents (52% female; Mean age=16.8), from eight different schools in the

Netherlands. In contrast to the previous studies, findings indicated that self-control was only positively related to breakfast intake (β=0.24) and no relationships between self-control and F&V and unhealthy snack intake were found, even after adjusting for socio-demographic characteristics (Junger & van Kampen, 2010). The lack of relationship with some of the dietary outcomes may be a consequence of the low average age of this sample, since the ability to self-regulate tends to evolve from adolescence to adulthood (Leon-Carrion, Garcia-Orza, & Perez-Santamaria, 2004; Williams, Ponesse, Schachar, Logan, & Tannock, 1999). Another potential reason for the lack of effect is that this study used a FFQ to assess dietary intake. Adolescents may experience particular difficulties in estimating portion size and frequency of consumption, which is a complex cognitive task for their developmental stage (Livingstone, Robson, & Wallace, 2004). Therefore, dietary data collected from adolescents are subject to a variety of errors, compromising their accuracy. A recent study conducted with an online sample of adults in the UK also did not find a significant effect of self-control (assessed using the SCS) on F&V intake (r=0.12; N=133) one week later (Evans et al., 2017). The study only found that self-control was inversely and significantly related to snack intake (r=-0.32; N=125). A potential reason for the lack of effect on F&V intake may be the small sample size and the use of a FFQ to assess dietary intake in the past week.

The use of other general measures of self-regulatory skills to explore the relationship between dietary behaviour and self-regulation has also shown small effect sizes. Kalavana, Maes, and De Gucht (2010) investigated the influence of self-regulation on healthy dietary behaviours in a cross-sectional sample of 473 adolescents (58% female; mean age=16.6 years old) who had a heathy eating goal. Self-regulation was assessed using three subscales of the Self-Regulation Skills Battery (SRSB): Goal commitment; Goal efficacy; and Goal ownership. Results for this study indicated that all self-regulatory skills were positively related to healthy eating (r=0.12 to 0.20) and negatively related to unhealthy eating behaviours (r=-0.10 to -0.13). However, regression analyses adjusting for socio-demographics and variables related to family and friends' environment showed that goal ownership and goal efficacy were significant predictors of a healthy diet, while only goal efficacy was a significant predictor of an unhealthy diet (Kalavana et al., 2010). Although a strength of this study was that it only included participants with an eating goal, a prerequisite to apply self-regulation, the scales measured general self-regulation and did not assess all aspects of self-regulation. Additionally, a FFQ was used to measure dietary intake among the adolescents, and as discussed previously, this might have led to some inaccuracies.

Kakoschke, Kemps, and Tiggemann (2014) also found a weak relationship between self-regulation and dietary behaviours in a sample of 146 undergraduates in Australia, when assessing self-regulation using the Barrat Impulsiveness Scale (BIS-11). Findings showed that motor and attentional impulsivity had a small but positive correlation with sweet and savory intake (r=0.16 to 0.19), while non-planning was not related to any of the dietary outcomes. Dietary intake was based on a taste task, and therefore did not represent usual consumption, which limits the conclusions that can be drawn from this study. Also, social desirability may have been a source of bias during the laboratory task, since the sample was composed only of women, who were on average normal weight. A longitudinal study also used the BIS-11 to investigate the association between self-regulation and dietary behaviours one week later in 154 undergraduate students (Mullah et al., 2014) in Australia. Similarly, impulsivity showed a weak and positive relationship to saturated fat intake (r=0.18), while no relationship was found for F&V. Since the BIS-11 only assesses the impulsivity aspect of self-regulation, the authors argued that there is still scope to understand the role of other self-regulatory skills such as planning skills, task switching and cognitive flexibility on dietary intake among undergraduate students. In line with this, a longitudinal study used the DEX questionnaire, which assesses the executive functions underlying self-regulatory actions to explore the relationship between self-regulation and F&V and snack intake in students (Allan et al., 2011). Although the results indicated a significant effect of self-regulatory skills on dietary intake three days later, the sample was too small (N=50) to draw any conclusions (Allan et al., 2011).

These studies show a small or even lack of effect of self-regulation on dietary behaviours and suggest that general measures are not adequate to assess eating self-regulatory skills. In an attempt to address this issue, a large population-based study developed and validated the 24-item Tempest Self-Regulation Questionnaire for Eating (TESQ-E) and assessed its relationship to dietary behaviours in a sample of 11,392 adolescents from nine different European countries (including the UK). As expected, the effect size of the relationship between eating self-regulatory skills and diet were slightly higher than the previous studies using general self-regulation measures. Eating self-regulatory competence was related to lower snack intake (r=-0.36) and soft drink intake (r=-0.25) and to higher fruit (r=0.30) and vegetable (r=0.21) intake (De Vet et al., 2014). However, a FFQ was used to measure dietary intake among the adolescents, which may have been a source of bias. Moreover, the items included in this scale are mainly related to specific strategies, and as people differ in their strategies to control their diet, the items may not be applicable to everyone. Furthermore, no items about self-monitoring, appraising progress and reviewing and amending goals were included.

Anderson-Bill et al. (2011) also used an eating-specific self-regulation measure to investigate the relationship between dietary intake and self-regulation in an online sample of 953 adults (83% female) and found positive results. Enactment of self-regulatory behaviors was a moderate predictor of participants' fat intake and a strong predictor of fiber, fruits, and vegetable intake. However, similar to the previous study, the self-regulation measure contains items covering specific strategies for healthy eating, which may not apply to everyone and does not cover important aspects of self-regulation, such as self-control.

Another cross-sectional study used the 43-item Behavioural Objective for Weight Management Scale (BOWM) to explore the relationships between weight management strategies and dietary behaviours among 407 adults in the United States (Nothwehr, Dennis, & Wu, 2007). The scores for the subscales relating to self-regulatory strategies for weight loss were inversely related to calorie intake. As 76% of the sample was overweight, this result may indicate that applying these strategies may help people to eat less and potentially lose weight. However, as not everyone has weight issues, this scale may neither be adequate to be applied in the general population, nor to explore self-regulatory skills that help individuals to maintain a healthy weight and diet.

Other studies have used items assessing action and coping planning related to dietary behaviours to assess self-regulation. Although planning is an important component of self-regulation, as shown in Chapter 1, these scales miss other relevant aspects of self-regulation such as self-monitoring, reviewing and amending goals and self-control. Schwarzer et al. (2007) adapted a 4-item scale to assess the effect of action planning on F&V intake at 4-week follow-up in an online sample of 700 German adults (72.8% female). Results indicated that action planning mediated the relationship between intention and F&V intake at 4-week follow up. These results are supported by a more recent online prospective study conducted with 909 German adults (81% female), in which action and coping planning mediated the effect of intention on F&V intake at 4-month follow-up (Gellert, Ziegelmann, Lippke, & Schwarzer, 2012). Similar results were found in a study conducted with two prospective samples of Dutch adults to explore the effect of action planning on F&V intake (N=572, 53.2% female) and on snacking intake (N=585, 48.9% female) at 3-month follow-up (van Osch et al., 2009). Action planning was measured using a 5-item scale adapted specifically to the outcome behaviours. The findings showed that action planning was a significant predictor of both dietary outcomes and mediated the effect of intention and actual behaviour at 3-months follow-up. This may be an indication that action planning helps people to translate their intention into actions. However due to the lack of baseline data on intake, it is not possible to know whether action planning helped people to maintain an intended behaviour or achieve it.

In contrast, Allan, Sniehotta, and Johnston (2013) showed that action planning did not independently predict snacking behaviours over a week in a sample of 72 university students (83% female). The 'Zoo Map' task was also used to assess planning skills, where participants had to plan how to visit multiple animals in different locations based on several rules and using the map of the zoo. The interaction between action planning with planning skills was on the borderline significance (p=0.05), suggesting that action planning only helped to overcome barriers to avoiding tempting food among skilled planners. However, these results should be interpreted cautiously as the sample was small and composed mainly by women. The follow-up was also smaller than the previous studies investigating action planning, which suggests that it may take more than a week for action planning to have an effect on dietary intake. Also, as with the previous studies it is not possible to know whether self-regulatory skills helped people to achieve a healthier diet or maintain it, as no baseline data for dietary intake was collected.

This issue was addressed in a study carried out by Reuter et al. (2010), which showed that changes in action and coping planning predicted changes in F&V intake at 4-week follow-up in an online sample of 853 adults in Germany. Another two studies also provided evidence for the impact of self-regulatory skills on dietary intake over time. Godinho, Alvarez, Lima, and Schwarzer (2014) investigated the relationship between F&V intake and coping planning and action control in a university sample in Germany (N=203; 85.2% female). A slight decrease in F&V intake was observed over 2 weeks (2.59 vs 2.43 servings/day). The effect of intention on F&V intake at 2-week follow-up (T3) was sequentially mediated by action control and coping planning (p=0.04). F&V intake at T3 was correlated to both action control (r=0.42) and coping planning (r=0.36). Similar results were provided in a study conducted with undergraduate students (N=286) in China (Zhou et al., 2015). A slight increase in F&V intake was observed over 2 weeks (4.29 vs 4.59 servings/day). Intention to eat F&V intake at 4-week follow-up (T3) was sequentially mediated by action control and action planning. F&V intake at T3 was also correlated with both action control (r=0.16) and coping planning (r=0.21), but the effect sizes were smaller than the previous study.

Overall, the evidence suggests a significant but small effect of self-regulation on eating behaviour. However, most of the studies used general measures to assess self-regulation, and assessing eating-specific self-regulation appeared to slightly improve the observed effect sizes. There is a lack of studies assessing the impact of self-regulatory skills on dietary changes or maintenance over longer periods of time. Additionally, the evidence was primarily from cross-sectional studies, meaning no conclusions can be drawn about causality, although these studies can help to explore a problem and establish new hypotheses that should be further examined using more rigorous research designs (Mann, 2003). Longitudinal studies measure events in a chronological order, and therefore are considered a more appropriate method to assess causal-relationships (Mann, 2003).

2.2.2 Relationship between eating self-regulatory skills and weight

Fewer studies were identified investigating the effect of self-regulation on weight control, compared to the effect of self-regulation on diet. All of the studies had a cross-sectional design and most of them used different measures to assess self-regulation. Price, Higgs, and Lee (2017) administered the SCS with 218 undergraduate students in the UK (17.4% male) and showed that self-regulation was weakly and negatively correlated with self-reported BMI (r=-0.15). They also found that self-control mediated the relationship between future time perspective (which refers to how individuals look at their future, as opposed to their present or past (Brothers, Chui, & Diehl, 2014)) and BMI. This suggests that having a higher expectation and consideration of future goals and values (e.g. maintaining a healthy weight) was related to lower BMI, among people with higher self-control. However, due to the cross-sectional design of this study, no conclusions about the direction of the relationship can be made. Although weight and height were self-reported, the results of this study were in line with other studies using objectively measured BMI. For example, Kinnunen, Suihko, Hankonen, Absetz, and Jallinoja (2012) found a negative and weak correlation between SCS and objectively measured BMI (r=-0.15) in a male adult sample (N=482) in Finland. However, in this cross-sectional study the SCS was shortened to match the age group's situation in life, that is – young male adults taking part in compulsory military service. These changes to the original scale may have compromised the validity and reliability of the SCS. A study administering a similar measure of self-control, the Habitual Self-control Questionnaire (HSCQ), with 2224 undergraduate students (42.3% male) in the US also found a weak, but positive correlation (r=0.22 to 0.35) between successful weight loss (≥10 pounds or 4.5kg) and self-control (Schroder, Ollis, & Davies, 2013). But it is important to note that data on successful weight loss were self-reported, which may have compromised the validity of this information. A recent study administering the Barrat Impulsiveness Scale (BIS-11) with a large cross-sectional sample from a French web-based prospective cohort (the NutriNet-Santé study, N=51,043) found that individuals with high impulsivity trait were more likely to be obese (Benard et al., 2017). However, similar to the previous studies, this cross-sectional study used a general measure and did not assess all the components of self-regulation.

Studies using scales that have been developed to assess self-regulatory strategies for eating and weight control, have demonstrated conflicting results for the relationship between self-regulation and BMI. Keller and Siegrist (2015) administered the 63-item Weight Management Strategies Inventory (WMSI) to assess eating and weight self-regulatory strategies within an online sample composed of 616 adults (51% female) from the German-speaking region of Switzerland. The results showed that inhibition and attention control strategies were related to higher self-reported BMI. The authors argued that people with a higher BMI might be trying to regulate their weight, while people with a lower BMI might not. However, the study did not compare self-regulation between weight status groups (e.g. overweight vs normal weight) and did not provide the sample's mean BMI, limiting the understanding of the results. Another study applied the 43-item Behavioural Objective for Weight Management Scale (BOWM) with 407 adults in the US (Nothwehr, Dennis, & Wu, 2007). The scores for the subscales relating only to eating self-regulation were positively but not significantly correlated to BMI. Therefore, this scale might also be assessing strategies for weight loss and not for a healthy diet and weight maintenance. As not everyone has weight issues, these scales may neither be adequate to be applied in the general population, nor to explore self-regulatory skills that help individuals to maintain a healthy weight and diet.

In contrast, other studies have found an inverse relationship between eating self-regulatory strategies and BMI. A study conducted with 120 Dutch adults (53% male) administered a 32-item Behavioural Strategies in Weight Management Scale (BSWM) to explore individuals' behavioural strategies to control the amount of food selected and consumed. This scale only included items related to eating regulation. The findings indicated that as eating behavioural strategies increased, self-report

BMI decreased (Poelman, de Vet, Velema, Seidell, & Steenhuis, 2014). However, when the same study was repeated in a different sample (N=278, 15.5% male) of people with a BMI ≥ 25 kg/m^2, no significant relationship between behavioural strategies and objectively measured BMI was found. The authors suggested that the use of the 32 eating behavioural strategies may be an indication of weight control efficacy, as it only discriminates normal weight from overweight and obese but not overweight from obese (Poelman et al., 2014). However, this interpretation might have been biased by the fact that self-report data was used in the first study and objective measures of BMI were used in the second one.

Another study also found an inverse relationship between self-regulation and self-reported BMI (r=-0.42 to -0.44) when applying the 3-item Perceived Self-regulatory Success in Dieting Scale (PSSDS) with 480 adults (Meule et al., 2012) in Germany. The administration of this scale in Dutch students produced similar results (Papies, Stroebe, & Aarts, 2008) for the relationship between self-regulation and self-report BMI (r=-0.48), although this sample included only 50 students. However, it is important to note that the PSSDS mainly assesses how confident people are about their ability to regulate their eating behaviour and weight, and people's reports of what they think they can do may not always represent what they actually do (De Ridder et al., 2012). Additionally, two items are about preventing weight gain (e.g. How successful are you in watching your weight?), and one item about losing weight (e.g. How successful are you in losing extra weight?), making this measure again only applicable to people who want to control their weight.

The evidence presented in this section showed conflicting results for the relationship between self-regulation and weight control. The studies varied in terms of the measures used to assess self-regulation, and no study used a comprehensive and valid measure to assess eating-specific self-regulatory skills. Due to the lack of longitudinal studies, no conclusions about the direction of the relationships could be made. Additionally, the impact of self-regulatory skills on weight changes and on the maintenance of a healthy weight has not been explored. Intervention studies could potentially enhance the understanding of the impact of self-regulatory skills on weight loss and dietary changes.

2.3 Evidence from intervention studies

The observational studies presented above suggest that higher self-regulatory skills predict healthier weight and diet, although many conflicting results and limitations were found regarding study design and the measures used to assess self-regulation and dietary and weight outcomes. In this section weight loss and dietary interventions promoting self-regulatory actions were assessed to understand whether self-regulatory skills can be enhanced through practice. The impact of these changes on the interventions effectiveness is also discussed. In total 18 intervention studies were found (Table 2.2). The approaches for delivering the weight loss and dietary interventions also varied greatly, the following were identified: 5 group-based interventions, 2 face-to-face brief interventions, 8 web-based and 3 mobile-based interventions.

Table 2.2 Evidence from intervention studies for the relationships between self-regulation, weight control and healthy diet

First author (year), country	Design	Mode of delivery	Sample	Intervention details/procedure	Self-regulation measure	Diet and weight measures	Relevant findings
Annesi et al (2014), USA	2-arm RCT	Group sessions	144 obese (BMI≥35 kg/m^2) adults; 78% female; M BMI=40.7 kg/m^2	Participants were randomized to receive 6 sessions (60 min each) over 12 weeks on **1)** PA and nutrition education **or**; **2)** PA and cognitive-behavioural methods for nutrition change. The cognitive and behavioural sessions covered aspects such as setting goals, self-monitoring, relapse prevention and managing cues on overeating. All participants were followed-up for 6 months.	Self-Management Strategies Scale (10 items) by Saelens et al (2000) adapted for controlled eating	Open question on the number of servings of F&V intake ''in a typical day'' over the past month.	At 6-month follow-up self-regulatory skills improved more in the group receiving cognitive and behavioural training (*p*=.004) than in the other one. Increases in F&V intake in the overall sample were predicted by increases in self-regulatory strategies over 6 months (*p*=.045).
Annesi, Johnson, Tennant, Porter, and McEwen (2016), USA	2-arm RCT	Group-sessions	110 Obese women, M age=42 yo; M BMI 35.3 kg/m^2	Participants were randomised to **1)** Exercise support (6 sessions) paired with self-regulatory training on nutrition behaviour change (sessions on weight loss -10; weight maintenance -4 and both -10) or **2)** comparison treatment consisting of 12 educational sessions on healthy eating and physical activity. Data were measured at baseline and months 3, 6, 12, and 24.	Self-Management Strategies Scale (10 items) by Saelens et al (2000) adapted for controlled eating	Open question on the number of servings of F&V intake ''in a typical day'' over the past month. Weight and height were measured.	Weight loss was greater in the experimental group over 6 and 24 months (p<.001). At 24 months, weight regain was only significant in the comparison group. F&V intake and self-regulatory skills increased more in the experimental group over 6 and 24 months (p<.01). Changes in self-regulation predicted weight loss and F&V intake.
Carter et al (2013; 2017), UK	Pilot 3-arm RCT	Mobile-based	128 overweight adults; M age=41; 77% female; M BMI=34 kg/m^2	Participants were randomly allocated to **1)** My Meal Mate app; **or 2)** Online food diary **or 3)** Paper Diary. The app consisted of an electronic food diary, where users could set goals and track their food and drinks intake. The online food diary consisted of the self-monitoring slimming website. The paper diary food was accompanied by a calorie-counting book. Participants were advised to follow the intervention during the first week and then as often as they pleased. Participants were follow-up over 6 months.	Consciousness scale (20 items) taken from the international Personality Item Pool website. It was also calculated the frequency of dietary self-monitoring.	Changes in BMI were calculated based on objectively measured weight and height.	At 6-month follow-up the frequency-of-use was higher for the app, followed by the website and diet diaries. BMI changes were greater in the app condition followed by diet diaries and website conditions. Analyses only within the app group showed that at 6-month follow-up those in the highest frequency-of-use category (recorded ≥129 days) lost more weight than those in the moderate and lowest categories (*p*<.001). Baseline scores for the Consciousness did not predict frequency-of-use of the app data.
Crane et al (2016), USA	2-arm RCT	Web-based	107 overweight male adults; M BMI=31.4 kg/m^2	Participants were randomized to **1)** REFIT intervention group **or 2)** waiting list control. The REFIT intervention involved 2 face-to-face group sessions followed by 13 online contacts, where participants were asked to record their weight and diet every week using an online link. Participants received automated and tailored weekly feedbacks, and had to choose a dietary strategy to work on in the following week. Participants were follow-up for 6 months.	Eating Behaviour Inventory (26 items) by O'Neil et al. (1979)	2 automated 24-h recall one during the week and one during the weekend. Daily calorie intake was calculated. Weight loss was calculated based on measured weight.	Greater weight loss was observed in the intervention group (M=-5.57kg) compared the waiting list group (M=-0.65kg) (*p*<.001). Self-regulation increased more in the intervention group (*p*<.001), and mediated the effect of the intervention on weight loss. The intervention group also reported greater decreases in calorie intake than the control group (*p*<.001). However, the effect of the intervention on calorie intake was not mediated by changes in self-regulation.

Table 2.2 Continue

First author (year), country	Design	Mode of delivery	Sample	Intervention details/procedure	Self-regulation measure	Diet and weight measures	Relevant findings
Crescioni et al. (2011), USA	PP	Group sessions	86 overweight adults; 71% female; M age=26.5; M BMI=31.3 kg/m^2	This 12-week weight loss program was adapted from the Diabetes Prevention Program. Participants were requested to attend weekly sessions and record their daily food consumption and exercise into a companion website.	Brief Self-Control Scale (13 items) by Tangney et al (2004)	A FFQ measured fat intake. From participants' diary data it was also calculated the weekly calories from fat. Weight loss calculated from objectively measured weight.	Self-control remained stable over the course of the intervention. Participants higher in self-control attended more meetings, consumed fewer calories and lost more weight over 12 weeks than those lower in self-control (p<.05).
Gholami et al. (2013), Iran	2-arm RCT	Brief	165 women; M BMI=27.1 kg/m^2	Participants were randomised **1)** dietary planning intervention **or 2)** control group. The intervention group received a package a containing information on fruits recommendation, instructions of how to perform the behaviour and action and coping planning exercises. The control group only completed the questionnaires. Participants were follow-up for 3 months.	2 items assessed coping and action planning.	Open question on the number of servings of fruit intake ''in a typical day'' over the past month.	At 3-month follow-up the intervention group increased their fruit intake more than the control group (p<.001) and this was mediated by increases in planning among women aged 30 or over, but not among young women aged 17 to 29.
Kattelmann et al. (2014), USA	2-arm RCT	Web-based	1,639 college students, M age= 19.3 yo; 67% female; 68% normal weight	Participants were randomised to **1)** online educational intervention or **2)** control group. The intervention consisted of 21 mini-online educational lessons and e-mail nudges messages over 15-month (10-week intensive with a 12-month follow-up). Participants were required to visit the website weekly to set goals e review their progress. Control group had only access to material after the intervention. All participants were assessed at baseline, 3 and15 months follow-up for primary and secondary outcomes.	4 items measured self-regulation for engaging in healthful mealtime behaviour (planning and specific strategies)	FFQ measured F&V and sweetened beverages intake. Fat intake over the past 12 month was assessed using the National Cancer Institute Fat Screener. BMI was calculated based on measured weight and height.	There were no differences between groups in BMI and weight at 3 and 15 months. There was a greater effect of the intervention group on FV intake, fat intake and self-regulation at 3 months, but these changes were only maintained for fat intake and self-regulation at 15 months.
Kolodziejczyk et al. (2016), USA	2-arm RCT	Web-based	404 overweight and obese university students, M age=22 yo; M BMI 29 kg/m^2; 70.3% female	Participants were randomised to **1)** the SMART intervention or **2)** a website. The SMART intervention was primarily delivered through Facebook and participants were encouraged to monitor their weight weekly and post their diet and physical activity. Participants assigned to the comparison group had access to a website without social networking components containing general health information relevant to young adults. Participants were followed up for 6 months.	Subscales of the Strategies for Weight Management Questionnaire addressing self-monitoring (4 items) and self-regulation (5 items)	FFQ assessed energy intake, whole grains, fruit, and oil and solid fat intake. BMI was calculated based on measured weight and height.	At baseline, only the self-regulation subscale was significantly related to diet variables. The intervention had a significant effect on self-monitoring scores, but not on self-regulatory scores. Change in self-monitoring and self-regulation scores were significantly related to changes in weight but not to changes in dietary variables.

Table 2.2 Continue

First author (year), country	Design	Mode of delivery	Sample	Intervention details/procedure	Self-regulation measure	Diet and weight measures	Relevant findings
Kreausukon et al (2012), Thailand	2-arm RCT	Group sessions	122 undergraduate students; 18 to 25 yo	Individuals were assigned to **1)** training session on action and coping planning and self-efficacy and general nutrition education **or 2)** general nutrition education (control group). All participants were followed-up for 6 weeks.	3 items measured action planning and 3 items measured coping planning related to F&Vs.	A FFQ (2 questions) measured F&V intake.	Only the intervention group improved their planning skills (*p*<.001). The intervention group had significantly greater F&V consumption at 6-week follow-up and this was mediated by improvements in planning skills and self-efficacy.
Lange et al. (2013), Germany	2-arm RCT	Web-based	791 adults; M BMI=25.61; M age=37.7; 79% female; 70% had an university degree	Participants were randomised to **1)** 1-h dietary planning intervention group **or 2)** control group. Participants in the intervention group were asked to commit to a specific fruit consumption goal, to plan when and where to perform their goal, to identify three barriers and plan how to overcome them and monitor their behaviour. The participants randomised to the control group received a knowledge-based quiz on nutrition. Participants were followed-up for 1 week.	2 items assessed coping and action planning. 3 items measure action control. All items were related to fruit consumption.	Open question on the number of servings of fruit intake ''in a typical day'' over the past month.	The intervention was more effective at both enhancing self-regulatory skills (planning and action control) and promoting positive dietary behaviour changes than the control group (*p*<.05). The effect of the intervention on fruit intake was mediated by both planning and action control and this model explained 23% of the variance of the fruit intake.
Lhakhang et al. (2014), India	Crossover RCT	Brief	205 students; 48% male; M age=20.7	The two group conditions received both the motivational and self-regulatory package intervention but in a different order. One of the intervention's packages was received after the baseline assessment **(T1)** and the second one 17 days later **(T2)** and a final follow-up repeated the assessments 17 days later **(T3)**. The motivational package involved F&V recommendation, benefits and costs and a motivational exercise. The self-regulatory package covered F&V recommendation and action and coping planning instructions and exercises.	3 items assessed action planning and 3 items assessed coping planning. Items were combined to represent 'dietary planning'.	2 open questions on the number of servings of F&V intake ''in a typical day'' over the past month.	In both group conditions dietary planning and F&V intake improved more after the self-regulatory package, as opposed to after the motivational intervention (*p*<.001). At T3, after both groups had received the same intervention components, but in a different order, participants who received the motivational package followed by the self-regulatory package increased their F&V intake the most (*p*<.001).
Luszczynska et al (2007), UK	3-arm RCT	Web-based	200 adults; 34% male; M age=28.9; 26% overweight; 58% had an university degree	Participants were assigned to **1)** self-efficacy intervention **or 2)** self-efficacy combined with planning intervention **or 3)** Control group. The planning intervention consisted of action and coping planning instructions and exercises. The self-efficacy intervention consisted of information on importance; feedback and how to improve self-efficacy. Participants were follow-up for 6 months.	2 items assessed action planning.	A FFQ measured F&V intake.	The combined intervention improved action planning more than the self-efficacy intervention alone (*p*<.001). The effect on F&V intake did not differ between the two groups, but was greater in the interventions than in the control group (*p*<.001).

Table 2.2 Continue

First author (year), country	Design	Mode of delivery	Sample	Intervention details/procedure	Self-regulation measure	Diet and weight measures	Relevant findings
McKee and Ntoumanis (2014), UK	2-arm RCT	Group-sessions	55 overweight or obese adults; M age= 37 yo; M BMI=32.6 kg/m^2; 72% female	Participants were randomised to **1)** self-regulation training or **2)** advice on diet and physical activity groups. Those in the self-regulation training condition did not receive any advice about physical activity or dietary choices. Both groups participated in a 3-hour workshop at baseline outlining the principals of the and had weekly practice tasks sent via email over 8 weeks. Physical, self-regulatory, and psychological measures were taken at baseline, end of intervention (week 8) and at follow-up (week 12).	12-item scale of six self-regulatory skills. Perceived Self-Regulatory Success in Dieting Scale (3 items) by Fishbach et al. (2003)	Weight and height were measured.	Self-regulatory skills improved significantly more over time in the training group than the advice one over 8 and 12 weeks (p=.01). Both groups reduced weight and increased perceived self-regulatory success, and no between-group differences were found.
Norman et al (2013), USA	2-arm RCT	Mobile-based	52 overweight adults; 80% female; M age=46; mean BMI=32.8 kg/m^2	Participants were randomised to text-messages intervention or control group. Participants in the intervention group received two to five automated and sometimes interactive (requested a reply) daily text-messages. Participants could choose the time of the day they wanted to receive the messages. They also received printed materials and monthly health counselling calls. Participants in the control group received only printed materials. Participants completed the study's questionnaires at baseline and 4-month follow-up.	Self-regulation was assessed using the 26-item Eating Behaviour Inventory by O'Neil et al. (1979)	Fruit and vegetable intake was measured with three 24-hour recalls. Changes in weight were calculated based on objectively measured weight.	Within group analyses showed that weight decreased (*p*=.003) and self-regulation increased (*p*<.001) significantly only in the intervention group. F&V intake did not change significantly in any group. The intervention group lost a greater amount of weight than control group (*p*=.051) and this was mediated by changes in F&V and in self-regulation.
Poddar et al. (2010), USA	Pilot 2-arm RCT	Web-based	294 students; 55% female; M age=20.2	Participants were randomly assigned to **1)** 5-week nutrition education intervention **or 2)** control group. The intervention consisted of weekly online courses and emails covering nutritional information about dairy foods and self-regulatory skills and a daily dietary checklist.	2 items assessed goal setting and self-monitoring of dairy intake.	7-day EFD. Total dairy intake (servings/day) and low-fat dairy (serving/day) were calculated.	Self-regulation increased more in the intervention group than the control group (*p*=.03), but no changes were observed for total and low-fat dairy intake.

Table 2.2 Continue

First author (year), country	Design	Mode of delivery	Sample	Intervention details/procedure	Self-regulation measure	Diet and weight measures	Relevant findings
Poddar et al (2012), USA	2-arm RCT	Web-based	211 students; 57% female; 76% normal weight; M age=20.2	Participants were randomised to **1)** the 8-week nutrition education intervention **or 2)** control group. The intervention consisted of weekly online courses and emails covering nutritional information about dairy foods and self-regulatory skills and a daily dietary checklist and received automated feedback based on their responses. Participants in the control group received information on stress management.	11 items on self-regulatory strategies to increase total dairy intake and low-fat dairy intake.	7-day EFD. Total dairy intake (servings/day) and low-fat dairy (serving/day) were calculated.	The intervention promoted greater increases in total dairy intake and self-regulatory skills compared to the control group (*p*≤.001).
Spook, Paulussen, Kok, and Van Empelen (2016), Netherlands	2-arm RCT	Mobile-based	238 students, M age=~17 yo;	4 schools took part and were randomised to **1)** Balance It app intervention or **2)** waiting list group. The app intervention consisted of an educational and strategic game that could be played on a daily basis. Data were collected online at baseline, 4-week follow-up (post-intervention) and 8-week follow-up.	4 items measured action planning and4 items measured action control. All items were related to dietary intake.	FFQ assessed F&V, snacks and soft drinks intake	No differences in dietary intake and action planning and coping planning were found between groups.
Springvloet et al (2015), the Netherlands	3-arm RCT	Web-based	1349 adults; 64% female; M BMI=25.6 kg/m^2; M age=49	Participants were randomised to **1)** basic tailored online intervention; **or 2)** plus (also targeting environmental-level factors) **or 3)** generic nutrition information (control group). The interventions were delivered through a website and participants were asked to visit it at least 3 times during a 2-month period. Basic and plus conditions encouraged participants to choose a target behaviour; set up action and coping plans; monitor their performance and evaluate their progress. The plus condition also had information on food-environment and on availability and price of healthy food. Participants were follow-up over 9 months.	6 items of the Self-Regulation Questionnaire by Carey (2004) and the Brief Self-Control Scale (13 items) by Tangney et al. (2004)	FFQ measured F&V, saturated fat and energy-dense snack intake. BMI was calculated based on self-report weight and height.	Fruit intake increased and snack and saturated fat intake decreased over time (*p*<.001), but no differences were found between the groups. Vegetable intake increased more in the basic group than in the other groups (*p*≤.05). Self-regulatory skills increased more in the control group (*p*=.04) than in the basic and plus conditions and although self-control increased over time (*p*<.001) no difference was found between groups. No intervention effect was found for BMI over time.

Note= PP: Pre- and Post-intervention. RCT: Randomised Controlled Trial. M: Mean. BMI: Body Mass Index. FFQ: Food Frequency Questionnaire. EFD: Estimated Food Diary. PA: Physical Activity. F&V: Fruit and Vegetables. yo= years old.

2.3.1 Impact of eating self-regulatory skills on dietary behaviour changes

Most of the dietary interventions promoting self-regulatory skills training included in this review resulted in increases in self-regulatory skills. However, due to the variability in terms of study design, the evidence is presented by mode of delivery.

2.3.1.1 Group sessions

Four interventions delivered through group sessions were identified and three of these showed encouraging results regarding the impact on eating self-regulatory skills and F&V intake. Annesi and Mareno (2014) investigated, with a two-arm randomised controlled trial (RCT), the impact of cognitive and nutrition education sessions on eating self-regulatory skills and F&V intake in severely obese adults (78% female). Self-regulation was assessed using the Self-Management Strategies Scale by Saelens et al. (2000) adapted for controlled eating. At 6-month follow-up, participants who received the cognitive and behavioural sessions on setting goals, self-monitoring, relapse prevention and managing cues on overeating improved their self-regulatory skills significantly more than those receiving the nutrition education sessions. Increases in F&V intake in the overall sample were predicted by increases in self-regulatory strategies over 6 months (Annesi & Mareno, 2014). However, no information on whether those in the behavioural and cognitive group sessions increased their F&V intake more than those in the comparison group was provided. This was addressed in a more recent 2-arm RCT conducted by Annesi et al. (2016) with 110 women with obesity. Similarly, participants were randomised to 1) exercise support paired with self-regulatory training on nutrition behaviour change or 2) comparison treatment encouraging the use of a manual on healthy eating and physical activity. F&V intake and self-regulatory skills increased significantly more in the experimental group compared to the comparison group over 6 months. Changes in self-regulation significantly predicted F&V intake at the 6 month follow-up. However, as with the previous study, the measure of eating self-regulation used was an adaptation of the measure developed by Saelens et al. (2000), which has not been validated nor had its psychometric properties evaluated. This poses a question of whether the measure used in this study is truly assessing eating self-regulatory skills.

Similar results were found in a RCT also comparing the effect of a cognitive (coping and action planning) session with a nutrition session, on eating self-regulatory skills and F&V intake among 122 undergraduate students (Kreausukon, Gellert, Lippke, & Schwarzer, 2012). Self-regulation was measured using items assessing coping and action planning related to F&V intake. At the 6-week follow-up, eating self-regulatory skills only improved among those that received the cognitive session. The comparison between the two groups showed that those receiving the cognitive session had significantly greater F&V intake at the 6-week follow-up and this difference was mediated by improvements in self-regulatory skills and self-efficacy. Therefore, this study suggested that promoting planning strategies may be superior to promoting nutrition knowledge only for improving dietary behaviours. However, these results should be interpreted with caution due to the small sample size, lack of information on the sample's gender and BMI and the fact that self-regulatory skills were not assessed using a comprehensive measure.

In contrast to the previous group sessions interventions, a 12-week weight loss program addressing healthy diet and psychological factors among 86 adults (70.9% female) did not improve self-regulation, assessed using the SCS (Crescioni et al., 2011). Multilevel analyses revealed that participants with high baseline self-control attended more meetings, and consumed fewer calories than those with low self-control. Participants were instructed to monitor their diet using a website, which could have potentially improved individuals self-monitoring skills. However, this was not possible to confirm, since the SCS does not assess self-monitoring skills. This study provided evidence that having greater dispositional self-control could be an important skill for achieving lifestyle goals, but the lack of a control group and small sample size compromises the interpretation of the results. The results for weight loss are discussed in section 2.3.2.1.

These four group-based studies highlight the potential importance of self-regulatory skills for the effectiveness of interventions, especially for the promotion of fruit and vegetable intake. However, none of them used a measure assessing the full range of self-regulatory skills and there is a lack of evidence for the effect of self-regulatory skills on breaking unhealthy eating habits. Additionally, face-to-face group-based interventions usually represent intensive, time consuming and costly weight loss and dietary interventions. Understanding the effect of brief and self-help interventions on promoting eating self-regulatory skills could inform the development of more accessible and cost-effective weight loss and dietary interventions.

2.3.1.2 Brief Interventions

Two studies were identified that explored the effect of brief self-help interventions on self-regulation and dietary behaviours. A two-arm RCT explored the effect of a brief planning intervention on F&V intake among 165 women (Mean BMI=27.12 kg/m^2) in Iran (Gholami, Lange, Luszczynska, Knoll, & Schwarzer, 2013). Participants in the intervention group received a package containing dietary recommendations, instructions, and exercises on action and coping planning whereas those in the control group received no input apart from completing assessment questionnaires. Self-regulation was assessed using two action and coping planning items. Findings showed that the intervention group increased their F&V intake more at the 3-month follow-up than the control group and this was mediated by increases in planning among women aged 30 or over, but not among young women (17-29 years old). The authors argued that middle-aged women have more experience and are more able to enact their plans. However, these differences among age groups may potentially reflect a lack of power to detect an effect of self-regulatory skills in the younger age group, lack of male participants, or the fact that an incomplete measure of eating self-regulatory skills was used.

Another brief intervention also explored the effect of self-regulation on F&V intake. Lhakhang, Godinho, Knoll, and Schwarzer (2014) conducted a crossover RCT with 205 (48.3% male) students in India, where both conditions received a motivational and self-regulatory package intervention, but in a different order. The motivational package intervention involved information on F&V intake recommendations, benefits and costs of action and inaction and an exercise asking participants to visualise the benefits of consuming more fruit and vegetables. The self-regulatory package intervention covered information on recommendation and action and coping planning instructions and exercises. Dietary planning was assessed using 6 items on action and coping planning related to F&V intake. In both conditions, planning improved more after the self-regulation package as opposed to after the motivation package. Participants who received the motivational package followed by the self-regulatory package increased their fruit and vegetable intake the most. This provides support for the Health Action Proposed Approach (HAPA) model, which suggest that first individuals need to be motivated to change and after that they need to acquire self-regulatory skills to translate their intention into action. However, this study only assessed planning skills as evidence of self-regulatory skills. Other self-regulatory skills, such as self-monitoring, reviewing and amending goals and self-control were neither assessed nor targeted in the intervention. Another limitation is that the intervention did not allow the identification of the active ingredient in each package. Also, the analyses were not adjusted for participants' prior intention to eat more F&V. It is likely that some variability existed regarding participants' intention to eat more F&V, and the motivation package would have a greater effect among those who had a low intention to eat more F&V.

Both studies suggest that action and coping planning may have the potential to improve eating self-regulatory skills (only planning skills), which in turn may have an effect on F&V intake. However, in both studies F&V intake was assessed using open questions, which rely on individuals' memory and ability to estimate portion sizes. Additionally, no brief face-to-face intervention exploring the impact of eating self-regulatory skills on unhealthy dietary intake was found. In sum, the results from these two brief interventions support the suggestion that self-regulation training has the potential to be delivered as a low-cost public health intervention, accessible to a large number of people, and at the same time to provide personalised guidance on exercising self-regulation for eating behaviours (Bandura, 2005). This kind of intervention also has the potential to be converted to a technology-based intervention, increasing its potential to reach an even larger number of people.

2.3.1.3 Web-based interventions

A total of 8 web-based dietary interventions were found, and in line with the previous section, most of these interventions aimed to improve F&V intake through enhancing planning skills. Luszczynska, Tryburcy, and Schwarzer (2007) conducted a 3-arm RCT to assess the effect of planning and self-efficacy training on F&V intake among 200 adults (24% male) in the UK. The self-efficacy intervention consisted of information on importance, feedback and how to improve self-efficacy. The planning intervention consisted of coping and action planning instructions and exercises. Two items assessed action planning, but no item was included to assess coping plans. The results showed that the combined self-efficacy and planning intervention improved action planning significantly more than the self-efficacy intervention alone. However, the effect on F&V intake did not differ between the two groups, although they increased their F&V intake more than the control group (Luszczynska et al., 2007). Therefore, in contrast to the brief interventions presented previously, promoting planning through a website did not seem to impact F&V intake. The lack of face-to-face contact might have influenced the results, as well as the intensity of the action and coping planning training.

Kolodziejczyk et al. (2016) assessed in a 2-arm RCT the effect of an online intervention promoting self-monitoring among overweight and obese undergraduate students (N=404). The intervention was primarily delivered through Facebook and participants were encouraged to monitor their weight weekly and post their diet and physical activity. Participants assigned to the comparison group had access to a website without social networking components containing general health information relevant to young adults. Self-regulation was assessed using the self-monitoring (4 items) and the self-regulation (5 items) subscales of the Strategies for Weight Management Questionnaire. The intervention had a significant effect on self-monitoring scores, but not on self-regulatory scores. However, in line with the previous web-based study, changes in self-monitoring scores were not related to intake of energy, whole grains, fruit, or oil and solid fat intake at 6-months follow-up.

More encouraging results were found with online planning interventions combining planning techniques with self-monitoring training. Lange et al. (2013) conducted a 2-arm RCT with 1154 (79% female) German adults to explore the effect of a brief (1-h) online planning intervention on fruit intake. Participants in the intervention group were asked to commit to a specific fruit consumption goal, to plan when and where to perform their goal, to identify three barriers and plan how to overcome them. They were also encouraged to monitor their behaviour. The participants randomised to the control group received a knowledge-based quiz on nutrition. Dietary planning was measured with two items and action control with three items (related to self-monitoring; appraising progress and effortful behaviour). At one-week follow-up fruit intake, dietary planning and action planning were greater in the intervention group compared to the control group. Furthermore, the effect of the intervention on fruit intake was significantly mediated by both planning and action control and this model explained 23% of the variance of the fruit intake. However, the longer-term effect of the intervention was not assessed, so it was not possible to draw any conclusions about the maintenance of these effects. Additionally, since the components could not be disentangled, it was not possible to assess whether both were active ingredients, or whether one of these would be sufficient to achieve the results seen. Also, not all aspects of self-regulatory skills were measured (e.g. self-control), and the sample was highly educated and composed mainly of women. Despite these limitations, this intervention provides evidence for the relevance of both planning and self-monitoring on fruit intake promotion.

In line with this, other online interventions including self-monitoring training have also produced positive effects on eating self-regulatory skills. Poddar, Hosig, Anderson, Nickols-Richardson, and Duncan (2010) conducted a pilot study to test the effect of a 5-week online course promoting dairy intake among 294 undergraduate students (55% female). Participants were randomly assigned to intervention or control group. Participants in the intervention group also received weekly online courses covering nutritional information about dairy foods and self-regulatory skills and were encouraged to complete a daily dietary checklist. Self-regulatory skills were assessed using two questions on goal setting and self-monitoring and dairy intake was collected using a 7-day food record. Although no changes were observed for total and low-fat dairy intake, self-regulation increased significantly more in the intervention group compared to the control group. The authors suggested that longer interventions would be required to achieve behaviour change in dairy intake. Based on this, Poddar, Hosig, Anderson-Bill, Nickols-Richardson, and Duncan (2012) developed an 8-week online intervention promoting dairy intake. A total of 211 undergraduate students (57.6% female) took part in the study and were randomised to an intervention or control group. However, in this study self-regulation was assessed using eleven items instead of two items, asking how often they used self-regulatory strategies to increase total dairy intake and low-fat dairy intake. Similar to the previous intervention, participants were asked to complete a weekly checklist to foster goal setting and self-monitoring and received automated feedback based on their responses. As hypothesized, this longer intervention promoted greater increases in total dairy intake and self-regulatory skills among the intervention group compared to the control group. Although these results suggest that changes in self-regulatory skills may lead to changes in total dairy intake, no mediation analyses were performed to confirm this. Also, these results should be taken with caution as only total dairy intake changed significantly, while no effect on low-fat dairy intake was found. The reported increase in total dairy (0.17 serving) was equivalent to 2 tablespoons, which may not represent an important change in practice.

Similar issues were found in a 2-arm RCT evaluating the effect of an online educational intervention combined with goal setting and reviewing progress tasks among young college students (N=1,639) (Kattelmann et al., 2014). Over 3 months, small improvements were found in self-regulation for engaging in healthful mealtime behaviour, and in F&V and fat intake. Although changes in self-regulation would be expected to be related to changes in dietary intake, no analyses were performed to explore these relationships. Additionally, although the self-regulation measure was designed specifically for eating behaviours, it did not include some relevant aspects of self-regulation that were addressed in the intervention, for example, reviewing and amending goals.

Springvloet, Lechner, de Vries, and Oenema (2015) also developed a web-based intervention promoting planning and self-monitoring skills to improve dietary intake, but contrary to the previous studies no effect on self-regulatory skills was found. In this study, 1349 Dutch adults participants (64.6% female) were randomised to one of three study conditions: 1) basic tailored online intervention; 2) plus (also targeting environmental-level factors) and 3) generic nutrition information (control group). The interventions were delivered through a website developed specifically for the study and participants were asked to visit it at least three times during a two-month period. Basic and plus conditions had four modules, each containing 3 sessions. After the first session of each module, participants were encouraged to choose a target behaviour, set up action and coping plans to achieve it, and monitor their performance. The second and third sessions gave participants the opportunity to evaluate their progress. The plus condition also had information on the home food-environment and on the availability and price of healthy food. Participants also received reminders to access the study website. Self-regulation was assessed using the general Self-Regulation Questionnaire (SRQ) and the general SCS. Dietary behaviours were assessed using a FFQ. The results showed that fruit intake increased and snack and saturated fat intake decreased over time, but no differences were found between the groups. Unexpectedly, SRQ scores increased more in the control group than in the basic and plus conditions. On the other hand, SCS scores increased over time in all groups and no differences were found between them. The authors argued that these results are a consequence of low adherence to the intervention, since the majority of the participants did not watch the second and third sessions of each module. Additionally, since many people taking part in this study were normal weight, it is possible that they already had high self-regulatory skills and therefore the skills training would not have been of great help for changing their dietary behaviours.

In line with this view, a 6-month online RCT, called REFIT (Rethinking Eating and fitness), delivered goal-setting, self-monitoring and planning training to overweight and obese male adults with promising results (Crane, Ward, Lutes, Bowling, & Tate, 2016). The intervention involved two face-to-face group sessions followed by 13 online contacts, where participants were asked to actively record their weight and diet every week using an online link. Participants also received automated and tailored weekly feedback, and had to choose a dietary strategy to work on in the following week. The main aim of the intervention was to reach the goal of making six 100-calorie changes per day. A total of 107 male (mean BMI=31.4 kg/m^2) adults took part and were randomized to the intervention group or a waiting list control group. Self-regulation was assessed using the 26-item Eating Behaviour Inventory by O'Neil et al. (1979). Dietary behaviours were assessed using two automated 24-h recall developed by the National Cancer Institute. The intervention group reported greater increases in self-regulation and larger decreases in calorie intake than the control group. However, the effect of the intervention on calorie intake was not mediated by changes in self-regulation. Limitations of the measure assessing self-regulation (EBI) may explain this unexpected result, as the EBI focuses mainly on self-regulatory strategies for weight loss and it seems to mix items related to eating behaviour traits and weight control strategies. Other limitations were the small sample and the inclusion of only male adults.

These web-based studies had conflicting results for the effect of planning and self-monitoring interventions on self-regulatory skills and dietary behaviours. However, the studies used different methods to assess dietary intake, some used a FFQ, while others used EFD or 24-h recalls. This is likely to have led to differences in the accuracy of dietary intake. The self-regulation measures also varied greatly in terms of their comprehensiveness and aspects of self-regulation measured, making comparison between studies difficult. Also, there is still a lack of evidence for the effect of web-based interventions on breaking unhealthy eating habits and the impact of self-regulation on these changes. Finally, the greater number of web-based interventions compared to those delivered face-to-face is likely to be a result of enthusiasm for new technology available for delivering dietary interventions in public health over the past decade.

2.3.1.4 Mobile-based interventions

The use of other technologies for dietary intake, such as mobile-based interventions is also growing due to the increase in smartphone ownership (Ofcom, 2014, Ofcom 2016). However, only two interventions were found exploring the effect of such interventions on self-regulatory skills. Norman, Kolodziejczyk, Adams, Patrick, and Marshall (2013) conducted a 2-arm RCT to test the effect of text-messages related to diet on F&V intake among 52 overweight and obese adults (80% female). The intervention group received text-messages covering goal setting, self-monitoring, and strategies for healthy eating and weight loss. Participants in the control group received only printed materials. F&V intake was measured using three 24-h recalls and self-regulation was assessed using the 26-item Eating Behaviour Inventory (EBI). At the 4-month follow-up, F&V intake had not changed significantly in any group, while EBI increased significantly in the intervention group only. However, similar to the results found in the REFIT study, no correlation between EBI score and F&V intake was found. As discussed before, future studies should aim to use measures that assess only the self-regulatory skills necessary to achieve and maintain healthy dietary behaviours and should not include items on weight loss. Other potential sources of biases were the small sample size and the high proportion of females taking part in the study. The effect of this intervention on weight loss is presented in the section below.

Spook et al. (2016) conducted a 2-arm RCT to investigate the effect of the Balance It app on adolescents' dietary behaviours (N=238). This consisted of an educational and strategic game that promotes self-regulatory skills and could be played on a daily basis. Data were collected online at baseline, post-intervention (4-week follow-up) and 8-week follow-up. Self-regulation was assessed using 4 items measuring action planning and 4 items measuring action control. Results showed no differences in dietary intake or planning between groups. A potential reason for this lack of effect might be the low engagement, as only 27.6% of people in the intervention condition actually used Balance It. Additionally, a FFQ was used to measure dietary intake among the adolescents, which may have been a source of bias.

Overall, there is a lack of studies exploring the effect of mobile-based dietary interventions on self-regulatory skills, which may reflect the novelty of this approach. No conclusions were able to be drawn, due to differences in sample size, populations and measures used in the two studies.

2.3.2 Impact of self-regulatory skills on weight loss

Following the same pattern found for the observational evidence described in section 2.2.2, fewer studies were found exploring the impact of self-regulatory skills on weight loss compared to dietary changes. Interventions delivered in the following formats were found: three group-based, two web-based and two mobile-based, and these are discussed separately below. No brief face-to-face weight loss interventions were identified.

2.3.2.1 Group sessions

The group-based 12-week weight loss intervention conducted by Crescioni et al. (2011), discussed in section 2.3.1.1, also assessed the effect of self-regulation on weight loss. The program was adapted from the Diabetes Prevention Program and participants were requested to attend weekly sessions and record their daily food consumption and exercise into a companion website. The 86 (71% female) participants were weighed and measured in every group meeting. Although self-control remained stable over the course of the 12-week intervention, those with higher self-control attended more meetings and lost more weight than those with lower self-control. However, this study failed to confirm that the relationship between self-control and weight loss was mediated by changes in diet and exercise. This unexpected result may be a consequence of the lack of control group, small sample size and measurement error for dietary behaviours assessed using a FFQ. Despite these limitations, there was a suggestion that having greater dispositional self-control may be an important prerequisite for losing weight, but this intervention did not prove to be adequate to improve general self-regulatory skills.

In contrast, the 2-arm RCT conducted by Annesi et al. (2016) with women with obesity (N=110) found that exercise support combined with self-regulatory training sessions promoted a greater increase in eating self-regulatory skills compared to nutrition education alone over 6 and 24 months ($p<0.001$). The intervention group also showed a significant greater weight loss than the nutrition education group over 6 months, and this was mediated by changes in self-regulatory skills. Weight maintenance at 24 months was also greater in the intervention group than comparison group, and this was predicted by increases in self-efficacy. Although these results support the relevance of enhancing self-regulatory skills for promoting weight loss, the lack of male participants compromises the generalisability of the results. Also, the measure of eating self-regulatory skills has not been validated nor had its psychometric properties evaluated, as explained previously in section 2.3.1.1.

A similar study compared the effect of self-regulatory training sessions providing only dietary and physical activity advice on weight loss and self-regulation among 55 overweight and obese adults (McKee & Ntoumanis, 2014). In this study, those in the self-regulation training (e.g. goal setting, self-monitoring, thoughts control, delay gratification, coping skills and mindfulness) condition did not receive any advice about physical activity or dietary choices, in order to understand the independent effect of training general self-regulatory skills. Although no between-group differences in weight loss or perceived self-regulatory success were found at 8 or 12 weeks, self-regulatory skills improved significantly more in the training group compared to the advice group ($p=0.01$). Results from this study may be an indication that self-regulatory training for weight loss should be eating-specific in order to provide a greater effect on weight. However, these results should be taken with caution due to the small sample size and the fact that the measure used was designed specifically to assess self-regulation of weight loss and no data of the validity of this measure were provided.

Overall, these group-based studies had conflicting results over the impact of changes in self-regulatory skills on weight loss among overweight and obese participants. However, differences in the design of the interventions and measures used to assess self-regulatory skills may have limited the conclusions. Also, the small sample sizes may reflect the intensive, time consuming and high cost features of group-based weight loss interventions. As a consequence, there is a growing interest in using new technology for lifestyle interventions for promoting eating self-regulatory skills.

2.3.2.2 Web-based intervention

As discussed in section 2.3.1.3, Kolodziejczyk et al. (2016) conducted a 2-arm RCT to assess the effect of the SMART online intervention among overweight and obese undergraduate students (N=404). The intervention encouraged participants to monitor their weight weekly and post their diet and physical activity on Facebook. As a result, the intervention promoted greater increases in self-monitoring scores than the control group, but no effect on self-regulatory scores was found. The study also showed that changes in self-monitoring and self-regulation scores were significantly related to weight loss over 6 months. This suggests that targeting self-regulatory skills training may help people lose weight. This assumption was supported in a 6-month online RCT (REFIT) conducted with 107 overweight and obese male adults (Crane, Ward, Lutes, Bowling, & Tate, 2016). As discussed in section 2.3.1.3, participants in the intervention group increased their self-regulatory skills through goal-setting, self-monitoring and planning training. Greater weight loss was also observed in the intervention group (M=-5.57kg) compared to the waiting list group (M=-0.65kg), and this was mediated by increases in self-regulation alongside other theoretical constructs, such as self-efficacy and autonomous motivation. The effect of the intervention on weight loss was also mediated by changes in calorie intake and self-weighing. However, the study had some limitations since weight was self-reported and self-regulation was assessed using the EBI which includes items related to other constructs. The fact that only men took part in this intervention also limits the generalizability of the results.

In line with previous studies, Kattelmann et al. (2014) found a significant effect of an online educational intervention combined with goal setting and progress review tasks on self-regulatory skills among young college students (N=1,639) over three months. However, no differences were found between the groups for BMI or weight at 3 or 15 months. This may be a consequence of 67% of the sample being of normal weight so maybe not having the intention to control or lose weight. Also, analyses were not carried out for the BMI groups separately, compromising the interpretation of the results.

In contrast, Springvloet, Lechner, de Vries, and Oenema (2015) did not find an effect of a web-based intervention promoting planning and self-monitoring on participants' self-regulatory skills (assessed using the SRQ and SCS). This study, which has been discussed in section 2.3.1.3, randomised 1349 Dutch adults to one of three study conditions: 1) basic tailored online intervention; 2) plus (also targeting environmental-level factors) and 3) generic nutrition information (control group). At 9-month follow-up no effect on self-reported BMI was found. The authors argued that these results are a consequence of low adherence to the intervention. Other potential sources of bias are that most participants were of normal weight and also that weight and height were self-reported.

Due to the limited amount of web-based weight loss interventions and contradictory results, it is not possible to draw many conclusions. However, the results from the REFIT and SMART RCTs suggest that there is some potential to improve self-regulatory skills in overweight and obese adults through goal setting, self-monitoring and planning training, which in turns leads to weight loss.

2.3.2.3 Mobile-based interventions

The evidence from technology-based delivered through mobile phones partially support the suggestions from the REFIT and SMART interventions. Carter, Burley, and Cade (2017) tested a mobile app facilitating goal setting, self-monitoring and feedback on performance among overweight and obese adults (N=128) and found positive results on weight loss, although no effect on self-regulation. Participants were randomised to one of the three conditions: 1) My Meal Mate app; 2) Paper Diary and 3) Online food diary. The pilot study involved minimal contact and participants were advised to follow the interventions during the first week and then as often as they pleased. Weight and height were measured at baseline, 6-week and 6-

month follow-up. Self-regulation was assessed using the 20-item Consciousness scale. At the 6-month follow-up, BMI changes were greater in the My Meal Mate app condition (-1.6kg/m^2), followed by paper diaries (-1.0 kg/m^2) and online diet diaries conditions (-0.5kg/m^2). Analyses within the app group alone showed that at 6-month follow-up those who had used the app the most (recorded ≥129 days) lost more weight than those using it only a moderate or low amount (p<0.001). Over the 6 months, the frequency-of-use was higher for the app (mean=92), followed by the website (mean=35) and paper diet diaries (mean=29) and the acceptability was also higher for the app compared to the other conditions. However, baseline scores for self-regulation did not predict frequency-of-use of the app (Carter et al., 2017), and it was not possible to know whether changes in self-regulatory skills predicted this, since these data were not collected. Additionally, no mediation analyses for the role of self-regulatory skills on the effect of the intervention on weight loss were performed.

A 2-arm RCT delivering text-messages on goal setting, self-monitoring and strategies for weight loss was found to increase both self-regulatory skills and promote weight loss among 52 overweight and obese adults (Norman, Kolodziejczyk, Adams, Patrick, & Marshall, 2013). As discussed previously in section 2.3.1.4, participants in the intervention group received two to five automated daily text-messages, while those randomised to the control group received printed materials and monthly health counseling calls. Self-regulation, assessed using the EBI, increased significantly in the intervention group only over 4 months. The intervention group also lost a statistically significant amount of weight (objectively measured) and the effect of the intervention on weight loss was mediated by changes in F&V and in EBI score. However, the limitations of the EBI mentioned before, combined with the fact that this study had a very small sample composed mainly of women compromises the generalizability of these findings.

These two studies suggest a positive effect of brief mobile-based interventions promoting self-regulatory skills on weight loss among overweight and obese adults. However these indications should be taken with caution since the identified studies lacked the power to detect significance differences and used non-comprehensive measures to assess eating self-regulatory skills.

2.4 Summary

Evidence from studies exploring the relationship between eating self-regulatory skills, dietary behaviour and weight control is encouraging but still very limited. The majority of the studies identified used general measures of self-regulation or measures including weight loss items, which are inappropriate for assessing self-regulatory skills related to healthy eating. Considering that general self-regulation questionnaires do not address specific eating strategies (De Vet et al., 2014), and that self-regulation of eating is likely to interact with biologically-mediated variation in appetite (Llewellyn & Wardle, 2015), behaviour-specific measures would be more appropriate for assessing eating self-regulatory skills. Also, most of these measures did not encompass the full range of components involved in the process of self-regulation of eating behaviour described in this thesis. A possible reason for that is because no comprehensive measure of eating self-regulation exists. The development and validation of an eating self-regulatory skills scale could fill this gap and help to better understand the role of eating self-regulatory skills on healthy dietary behaviours and weight control at the population level.

The majority of the observational studies identified had cross-sectional designs, which cannot indicate causality. Prospective studies addressing these questions were mainly conducted with undergraduate students. Although the transition to university tends to promote weight gain and unhealthy dietary changes (Vella-Zarb & Elgar, 2009), no study assessed the effect of self-regulatory skills on these changes. Besides, the majority of these studies had very short follow-ups and small sample sizes, composed mainly of women. There is therefore a need for well-designed prospective studies investigating the impact of self-regulatory skills on the maintenance of healthy dietary behaviours and weight over the first year at university. This proposition has also been supported by other researchers (Guillaumie, Godin, & Vezina-Im, 2010).

Evidence from intervention studies suggested that brief and technology-based interventions targeting action and coping planning have the potential to promote self-regulatory skills and healthy dietary behaviours, especially F&V intake. However, the results were not entirely consistent due to differences in the measures used to assess self-regulatory skills and limitations in the studies designs. The planning techniques used in these studies aimed to increase the automaticity of the initiation of goal-directed behaviours (Gollwitzer, 1999) , which could help people to successfully implement their intentions. These techniques can also be interpreted as habit-based planning when they are designed to be repeated consistently in the same daily context (Gardner, Lally, & Wardle, 2012; Lally & Gardner, 2013). However, it is not clear whether these interventions had a habit approach, since none of them explicitly stated that the action plan should be consistently repeated in the same context in order to form new habits. Although it has been argued that planning interventions with a habit approach may be more effective at promoting lasting healthy lifestyles (Beeken et al., 2016; Lally et al., 2008; Sniehotta, 2009), the effect of habit-based interventions on eating self-regulatory skills remains unclear. Future studies should also investigate the effect of changes in eating self-regulatory skills on breaking unhealthy eating habits.

Regarding the impact of self-regulatory skills on weight loss, the evidence was less clear due to the small number of studies found. The findings suggested that brief technology-based interventions using goal-setting, planning, self-monitoring and feedback on performance techniques may potentially promote self-regulatory skills and weight loss among overweight and obese adults. However, most of the studies identified did not have the power to detect weight differences and did not use a comprehensive measure to assess eating self-regulatory skills. Additionally, no brief face-to-face study has been identified looking at the impact of self-regulatory skills changes on weight loss. The development of brief interventions promoting self-regulatory skills and delivered face-to-face or through smartphones could fill the gap in lifestyle advice that is convenient, appealing, cost-effective, wide-reaching and can be delivered with minimal time.

Therefore, future studies should test the effect of brief habit-based interventions, delivered face-to-face or via new technologies, targeting goal setting, planning and self-monitoring on eating self-regulatory skills among overweight and obese adults. According to Bully, Sanchez, Zabaleta-del-Olmo, Pombo, and Grandes (2015), in-depth analyses of the mechanism of action of lifestyle interventions will inform the development of more effective interventions. Therefore, whether an increase in eating self-regulatory skills is the underlying mechanism by which these interventions promote weight loss and healthy dietary behaviours (including breaking unhealthy eating habits) should also be investigated. This may help to elucidate the mechanisms of action of brief weight loss habit-based interventions and provide more evidence for the role of eating self-regulatory skills on achieving and maintaining healthy lifestyle behaviours.

CHAPTER 3: RESEARCH AIMS OF THE CURRENT THESIS

3.1. The key questions this thesis aims to address

Recent studies have suggested that the ability to self-regulate eating behaviour may help people to cope with the obesogenic environment and achieve, as well as maintain, a healthy weight and diet. However, most studies exploring relationships between eating self-regulatory skills, weight control and dietary behaviours in adults have used cross-sectional designs, which cannot indicate causality. Moreover, the majority of studies have not accounted for the full range of eating self-regulatory skills, and a possible reason is that no comprehensive measure of eating self-regulation exists. It has also been suggested that it may be possible to enhance self-regulatory skills through practice. There are indications that brief face-to-face and mobile-based lifestyle interventions targeting goal-setting, planning, self-monitoring and feedback on performance may be effective at enhancing eating self-regulatory skills. However, no evidence for the effectiveness of brief weight loss interventions with a habit formation approach has been found. Additionally, the impact of increased self-regulatory skills on weight control and dietary behaviours is still not clear.

Therefore, the overall aim of this thesis was to develop a measure to assess eating self-regulatory skills in the general adult population to investigate whether 1) eating self-regulatory skills help with maintaining a healthy diet and preventing weight gain; 2) brief habit-based weight loss interventions can enhance eating self-regulatory skills; and 3) improvements in eating self-regulatory skills lead to healthy dietary behavioural changes and weight loss.

Specifically, the objectives of this thesis are:

1. Design and validate a psychometric measure to assess eating self-regulatory skills in the general adult population;

2. Examine the relationships between eating self-regulatory skills, weight and dietary behaviours over 6 months in an online longitudinal cohort of undergraduate students;

3. Test the effect of a brief face-to-face habit-based weight loss intervention on eating self-regulatory skills; and the impact of self-regulatory skills changes on weight loss and dietary behavioural changes over 3 months in an obese adult population-based sample;

4. Develop an app version of the brief habit-based weight loss intervention and pilot it in a sample of overweight and obese adults, exploring its potential to promote eating self-regulatory skills, dietary changes and weight loss.

Four studies were designed to address each of these objectives. Objective 1 is addressed by study 1 (chapter 4), which describes the development and validation of the Self-Regulation of Eating Behaviour Questionnaire (SREBQ) for the general adult population. This chapter presents the piloting and provides evidence for its factor structure internal and external reliability and construct validity.

To meet objective 2, Study 2 (Chapter 5) assesses the relationships between eating self-regulatory skills, weight and dietary behaviours in a 6-month online cohort of first year undergraduate students from London, UK. This study investigates whether high eating self-regulatory skills at baseline protects students against substantial weight gain (≥5% initial body weight), and whether it predicts a healthy diet at 6-month follow-up.

Objective 3 is addressed by study 3 (Chapter 6), which is a secondary analysis of data from the 10 Top Tips (10TT) trial, a habit-based weight loss intervention developed as a leaflet and delivered face-to-face to obese adults in primary care. It was a two-arm, individually-randomised (1:1 ratio), controlled trial, comparing the 10TT intervention with ‘Usual care’. This study explores the effect of the 10TT on self-regulatory skills and whether increases in self-regulatory skills mediate the effect of the 10TT intervention on dietary behaviour changes and weight loss over 3 months (post-treatment effect). Since this study was conducted before the development of the SREBQ (Chapter 4), the 31-item Self-Regulation Questionnaire - SRQ (Carey et al., 2004), adapted for eating and weight loss was used to measure self-regulatory skills.

Finally, objective 4 is met by Study 4 (Chapter 7), which involves the development of an app version of the 10TT intervention and its piloting with a sample of overweight and obese adults. The pilot study randomised participants into 1) Top Tips app only; 2) Top Tips app plus (including strategies to deal with tempting foods) and 3) passive control group. This study explores the effect of the Top Tips app on self-regulatory skills and the relationship between self-regulatory skills changes and changes in dietary behaviour and weight loss over 3 months. It also explores whether promoting self-regulatory strategies to deal with unhealthy foods (Top Tips app plus) is more effective at improving eating self-regulatory skills and dietary and weight outcomes compared to the Top Tips app only. In this study both the SREBQ, developed as part of this thesis (Chapter 4), and the 31-item SRQ (Carey et al., 2004) adapted for eating and weight loss were used to measure self-regulatory skills.

3.2 My contribution to the research in this thesis

I played a lead role in developing the thesis aims and designing each of the 4 studies, with input from my supervisors, Dr Rebecca Beeken, Dr Fiona Johnson and Dr Helen Croker. During the first two years of my PhD I also had input from Professor Jane Wardle, who was acting as my primary supervisor at that time.

For Study 1, I developed the psychometric measure, designed the pilot and factor structure studies and collected the data. I also designed the confirmatory factor analysis study and, contacted an independent research agency, which was responsible for collecting the data for this study. I applied for the ethical approval and designed and conducted all analyses independently.

I conducted all aspects of Study 2 that is, I designed the study and developed all the online material. I applied for the ethical approval and was also in charge of the data collection. This included contacting all the Schools and Departments of the Universities participating in this study and asking them to forward the online questionnaire to their first year undergraduate students. I designed and conducted the analyses independently.

For study 3, I was provided with data from the 10 Top Tips Trial (10TT), by Dr Rebecca Beeken, who was the coordinator of this project. I performed all the analyses myself, although I sought advice from a statistician collaborating on the project, Ms Victoria Vickerstaff, on the most appropriate statistical methods to use.

For Study 4, I was involved in the entire process of the development of the Top Tips app, from the selection of the App Agency to the pilot testing. My main role was to coordinate the communication between the Agency and the Research team (all my supervisors) involved in this project. I developed the breaking habits tip added to the second version of the app, with input from my supervisors. I was also responsible for designing the pilot study, and collecting the data. I designed and conducted the analyses independently.

During my PhD I have also worked on a number of papers, and presented some of my work at national and international conferences. A list of papers I have worked on and the conferences I attended are shown in Appendix 3.1.

CHAPTER 4: DEVELOPMENT AND VALIDATION OF THE SELF-REGULATION OF EATING BEHAVIOUR QUESTIONNAIRE FOR ADULTS (Study 1)[1]

4.1 Introduction

As discussed in Chapter 1, it has been suggested that the ability to self-regulate eating behaviours may moderate individual susceptibility to the obesogenic environment and support the maintenance of a healthy weight and diet (Johnson et al., 2012; Kroese et al., 2009). Behavioural self-regulation is likely to be a relatively stable construct (Hagger, 2014), but one that can be improved through practice (Hofmann, Schmeichel, et al., 2012; Johnson et al., 2012). As a consequence, promoting self-regulation training may have the potential to support successful weight control (Llewellyn & Wardle, 2015) and the formation of healthy dietary habits (Gardner, Lally, & Wardle, 2012). In order to test this and to determine the effectiveness of interventions it is imperative to have a valid and reliable measure of eating self-regulatory skills.

However, as shown in Chapter 2, a comprehensive, reliable, and valid questionnaire to assess eating self-regulatory skills in adults is currently lacking. The majority of the studies presented in Chapter 2 used general measures of self-regulation (Carey, Neal, & Collins, 2004; Mezo, 2009; Moilanen, 2007; Schroder, Ollis, & Davies, 2013; Tangney et al., 2004), which may be inappropriate to assess self-regulatory skills specifically related to healthy eating. Self-regulation is likely to interact with biologically-mediated variation in appetite and general self-regulation questionnaires show only modest associations with healthy eating behaviours and weight control (Junger & van Kampen, 2010; Kennett & Nisbet, 1998; Mezo, 2009; Schroder et al., 2013). A recently published questionnaire, the Tempest Self-Regulation

[1]A version of this chapter has been published in IJBNPA (Appendix 4.1)

Questionnaire for Eating (TESQ-E), has addressed this gap (De Vet et al., 2014), but it was specifically designed to assess adolescents' eating self-regulation strategies for healthy eating. Additionally, most of the currently available measures, including TESQ-E, do not encompass the full range of components involved in the process of self-regulation of eating behaviour described in this thesis, such as setting goals, self-monitoring, appraising progress and reviewing and amending goals.

Additionally, some psychometric scales assessing eating behaviours have items that measure self-regulation components, but none assess self-regulation of eating behaviour uniquely and comprehensively. For example, Chapter 1 mentioned that the construct of dietary restraint (Herman & Mack, 1975; Johnson et al., 2012) overlaps with self-regulation, but restraint scales also assess a range of personality traits and eating tendencies (such as susceptibility to overeat and weight fluctuation, self-efficacy, appetitive traits and food choices) (Laessle et al., 1989; Williamson et al., 2007). Correlations between measures of dietary restraint and dietary intake are generally weak, and the presence of multiple constructs in restraint scales may account for the inconsistent results published over the past 40 years on the relationship between cognitive control and weight (Johnson et al., 2012; Laessle et al., 1989; Williamson et al., 2007). Scales assessing dietary restraint also assume a goal of weight loss, which may not always be central to dietary intentions (De Vet et al., 2014a; Fishbach et al., 2003; Keller & Siegrist, 2015; Kolodziejczyk et al., 2015; Nothwehr, Dennis, & Wu, 2007; Schlundt & Zimering, 1988). Therefore, at present no established and standardized self-report measures exist to assess eating self-regulatory skills in the adult population. The development and validation of an eating self-regulatory skills scale could fill this gap and help to better understand the role of eating self-regulatory skills in obesity prevention at the population level.

4.2 Study aims and contribution to the literature

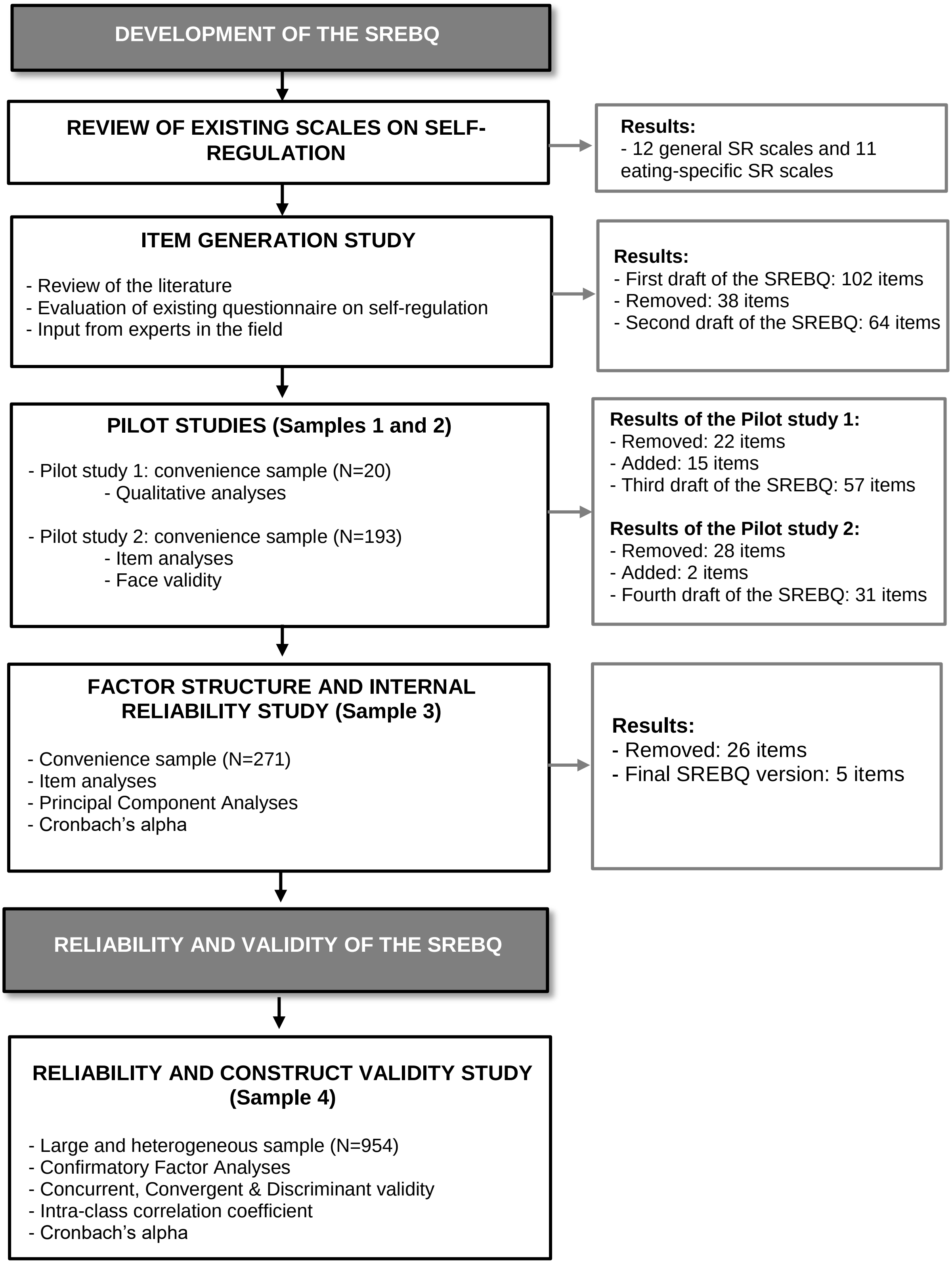
This chapter reports the development and validation of the Self-Regulation of Eating Behaviour Questionnaire (SREBQ) for adults. As goals are a prerequisite to applying self-regulation (Carver & Scheier, 2001), the relevance of the SREBQ is limited to individuals who have an intention to either have a healthy diet or to not eat too much of foods they find tempting. Hence, the SREBQ measures self-regulatory skills relative to eating intentions already established by the individual. It should also be clear that the SREBQ does not aim to assess each of the individual components involved in the process of self-regulation in isolation, nor what specific strategies people have to control their eating. The purpose of the SREBQ is to assess how capable someone is at regulating their eating, and it takes into account the skills needed to successfully self-regulate healthy eating behaviour.

This chapter aims to present the reliability of the SREBQ, and to provide evidence for its construct, convergent, discriminant and concurrent validity. The development and validation of this new self-report scale of eating self-regulatory skills will help to assess this construct in the adult population in a reliable and consistent way. It will allow comparison between studies as well as permitting the effectiveness of interventions targeting eating self-regulatory skills to be determined.

4.3 Methods and Results

The development of the SREBQ involved a review of existing scales, followed by an item pool generation, two pilot studies and a study exploring the questionnaire’s underlying factor structure and internal reliability. The final version of the SREBQ was then administered to a different sample and had its reliability and construct validity assessed, as shown in Figure 4.1. The results are presented per stage of the development and validation of the SREBQ.

Figure 4.1 Flow diagram of the development and validation of the Self-regulation of Eating Behaviour Questionnaire



4.3.1 Development of the Self-regulation of Eating Behaviour Questionnaire

4.3.1.1 Scoping review of the existing questionnaires on self-regulation

Aim

This scoping review aimed to evaluate the reliability and validity of the existing self-regulation scales, in order to i) confirm the need for a new scale on eating self-regulatory skills and ii) identify valid and reliable items assessing self-regulatory skills.

Method

A detailed literature search was carried out in PubMed, Web of Science, Scopus and PsychINFO databases (up to 2014). The search strategy can be found in Appendix 4.2. Reference lists of relevant literature were also checked for additional scales. Only peer-reviewed papers published in English that developed or investigated psychometric properties of self-report measures of self-regulation were included. Scales had to claim to be assessing self-regulatory processes or abilities, as defined in Chapter 1. Scales designed to assess self-regulatory skills related to chronic disease management (e.g. diabetes) or psychiatric illnesses (e.g. eating disorder) were excluded. Subscales of broader instruments adapted for assessing the effect of a specific intervention were also excluded. As there is an overlap between what are considered older adolescents and young adults in different studies, scales for both groups were included. Psychometric scales assessing general self-regulation and self-regulation of eating behaviour were explored separately.

Results

The search resulted in 1371 papers, which were reduced to 852 papers after removing duplicates (see the flow chart in Appendix 4.3). Following title, abstract and methods screen, 17 scales assessing self-regulatory skills were found; 9 were general scales and 8 were eating-specific scales. An additional 3 general scales and

3 eating-specific scales were identified from reference lists. Details of the 12 general self-regulatory skills scales and 11 eating-specific self-regulatory skills scales are presented in Table 4.1 and Table 4.2, respectively.

Table 4.1 Content, validity and reliability information about the general self-regulatory scales

#	Name of the questionnaire (references)	N° items	Content	Processes of self-regulation (underlying ability)	Reliability	Validity	Relationship with diet/weight
1a	**Self-Control Test** (Flora, Finkel, & Foshee, 2003; Grasmick, Tittle, Bursik, & Arneklev, 1993)	24	Impulsivity; preference for simple rather than complex tasks; risk seeking; preference for physical rather than cerebral activities; self-centredness and volatile temper	**Planning; Persistence** (behaviour, attention, thoughts, emotions control)	α^a=.91	PCA; CFA	No associations between SCT and diet/weight variables were performed
2a	**Self-Control Schedule Scale** (Rosenbaum, 1980)	36	Emotional and inhibition control; coping skills; delay immediate gratification; and perceived self-efficacy	**Goal setting; Planning; Awareness of actual behaviour and Persistence** (feeling; attention; thoughts; behaviour and environmental control)	α^a=.78-.84 r^b=.86	CV; DS	No significant differences in self-control between normal weight and overweight adults were found
3a	**The Lifestyle Approaches Inventory** (Mezo & Heiby, 2004; R. L. Williams, Moore, Pettibone, & Thomas, 1992)	16	Cognitive and behavioural self-management, self-efficacy and health habits	**Goal setting; Planning; Persistence Evaluating; Adjustment; Self-monitoring** (attention, behaviour, environment control)	α^a=.81 α^b=.91	PCA; CC; CV; DS	r=.32 (weight management vs LAI) r=.27 (health status vs LAI) r=.32 (health habits vs LAI)
4a	**Barratt Impulsiveness Scale - BIS-11** (Fossati, Di Ceglie, Acquarini, & Barratt, 2001; Patton, Stanford, & Barratt, 1995)	30	Attentional impulsiveness; motor impulsiveness and non-planning impulsiveness	**Planning** (behaviour, attention, thoughts control)	α^a=.79-.83	PCA; DS	r=.18 (alcohol intake vs impulsiveness)
5a	**UPSS Impulsive Behaviour Scale** (G. T. Smith, Fischer, Cyders, Annus, & Spillane, 2007; Whiteside & Lynam, 2001)	45	Urgency; (lack of) premeditation; (lack of) perseverance; sensation seeking	**Planning; Persistence** (behaviour, attention, thoughts, emotions control)	α^a=.82-.91 r IT=.38-.79	PCA, CV, DS	r= -.21 (binge eating vs planning)
6a	**Self-Regulation Questionnaire** (Carey et al., 2004)	31	Receiving and evaluating information; triggering change; searching for options; formulating and implementing a plan; assessing a plan	**Goal setting; Self-monitoring; Persistence; Planning; Evaluating and Adjustment** (feelings; behaviour; thoughts; attention control)	α^a=.92 r IT=.42-.72	PCA, CC, CV	No significant correlation between self-regulation and alcohol consumption was found

Table 4.1 Continue

#	**Name of the questionnaire** (references)	**N^{o} items**	**Content**	**Processes of self-regulation** (underlying ability)	**Reliability**	**Validity**	**Relationship with diet/weight**
7a	**Self-Control Scale** (Tangney et al., 2004)	36 (13)^	Self-discipline; deliberate/Non-impulsive action; healthy habits; work ethic and reliability	**Persistence** (Behaviour, attention, thoughts, emotions control)	α^a=.83-.89 α^b=.87-.89	PCA; CV	r=-.31 to -.32 (alcoholism vs self-control)
8a	**Self-Regulation Scale** (Diehl, Semegon, & Schwarzer, 2006)	10	Attention, behaviour; thoughts, and emotion regulation	**Goal-setting; Persistence; Planning** (Feeling; behaviour; thoughts and attention control)	α^a=.74-.82 α^b=.62 r IT=.36-.61	CV	No associations between SRS and diet/weight variables were performed
9a	**Self-Control & Self-management Scale** (Mezo, 2009)	16	Self-monitoring; self-evaluating; reinforcing	**Self-monitoring; Goal-setting; Planning**; **Persistence** (Attention and thoughts control; Persistence)	α^a=.74-.81 α^b=.62-.75	PCA; CV ; DS	r=.30 (weight management vs self-evaluating subscale; not significant for the other subscales)
10a	**Habitual Self-Control Questionnaire** (Schroder et al., 2013)	14	Action control; motivation for action control	**Persistence** (behaviour and thoughts control)	α^a=.81 α^b=.83 r IT=.32-.53	PCA; CV; CC; DS	r=.22 to .35 (weight control vs self-control) r=.05 to-.11 (alcohol intake vs self-control)
11a	**Adolescent Self-Regulation Questionnaire** (Dias, del Castillo, & Moilanen, 2014; Moilanen, 2007)	36	Ability to override behavioural, attentional and emotional impulses; action planning and controlling impulses	**Goal setting; Self-monitoring; Persistence; Planning; evaluating and adjustment** (feelings; behaviour; thoughts; attention control)	α^a=.75	PCA; CFA; CC; CV	r=.12 to .19 (self-regulation vs alcohol intake)
12a	**Behavioral Assessment of the Dysexecutive Syndrome** (Gerstorf, Siedlecki, Tucker-Drob, & Salthouse, 2008)	20	Emotional and personality changes; motivational changes; Behavioural and cognitive changes	**Goal setting; Planning; Persistence (**Behaviour, attention, thought and feeling control)	α^a=.91	CFA; CV	r=-.20 (health status vs dysexecutive problems)

Note= ^Number of items of the Short version scale. CV=Convergent validity. CC=Concurrent validity. DS= Discriminant validity. PCA= Principal Component Analysis. CFA=Confirmatory Factor Analysis. α^a= Internal reliability Cronbach's alpha. α^b=Test-retest reliability. r^b=Test-retest reliability Pearson's Correlation. r IT= Item-total correlation. r=Pearson's or Spearman's correlations

Table 4.2 Content, validity and reliability information about the eating-specific self-regulatory scales

#	Name of the questionnaire (references)	N° items	Content	Processes of self-regulation (underlying ability)	Reliability	Validity	Relationship with diet/weight
1b	**Eating Behaviour Inventory** (O'Neil et al., 1979b; O'Neil & Rieder, 2005)	26	Self-monitoring of food intake and of weight; refusing offers of food, eating at only one place; shopping from a list; eating in response to emotions	**Self-monitoring, Goal setting; Planning; Adjustment; Evaluation** (behavioural, feeling; attention, environmental control)	α[a]=.62 r[b]=.74 r IT=.16-.58	CV	r=.34 to .74 (changes in EBI vs weight loss)
2b	**Dieter's Inventory of Eating Temptations** (Schlundt & Zimering, 1988b)	30	Overeating; negative emotions; exercise; resisting temptations; social situations; food choices	**Planning** (behaviour; attention; thoughts and environmental control)	α[a]=.68 r[b]=.68-.92	CV	Normal weight showed a higher total DIET score than overweight (p<.01).
3b	**Flexible and Rigid Restraint of the Three-Factor Eating Questionnaire** (Shearin, Russ, Hull, Clarkin, & Smith, 1994; Westenhoefer, 1991)	28	Flexible and rigid control; beliefs; disinhibition	**Planning; Self-monitoring, Persistence** (behaviour, attention control)	α[a]=.77-.80	CV	r=-.45 (BMI vs flexible control subscale)
4b	**Perceived Self-Regulatory Success in Dieting Scale** (Fishbach et al., 2003; Meule et al., 2012)	3	How successful people are in watching their weight; losing weight and stay in shape	**Self-monitoring; Evaluation** (behaviour; attention; thoughts control)	α[a]=.72-.79	PCA; CV; DS	r=-.22 (rigid restraint vs PSRSDS) r=-.26 (flexible restraint vs PSRSDS)
5b	**Behavioural Objectives for Weight Management** (Nothwehr et al., 2007)	43	Self-monitoring; action planning; adjustment behaviours; self-reward; strategies for diet and weight control (portion control, preparing/buying etc.); searching for health information	**Goal setting; Self-monitoring; Persistence; Planning; Reviewing and Amending goals** (behaviour; thoughts; attention; environmental control)	α[a]=.73-.90 α[b]=.62-.85	PCA; CV	None of the eating subscales were correlated to BMI r=-.13 to -.33 (energy intake vs BOWM subscales)
6b	**Weight-related eating questionnaire** (Schembre, Greene, & Melanson, 2009)	16	Routine restraint; compensatory restraint; susceptibility to external cues; emotional eating	**Planning; Self-monitoring; Adjustment; Evaluation** (behavioural; feeling control)	α[a]=.75-.90	PCA; CFA; CV; CC	r=-.13 (Fat intake vs routine restraint subscale) r=.16 (F&V intake vs routine restraint subscale)

Table 4.2 Continue

#	Name of the questionnaire (references)	N^{o} items	Content	Processes of self-regulation (underlying ability)	Reliability	Validity	Relationship with diet/weight
7b	**Delaying Gratification Inventory** (Hoerger, Quirk, & Weed, 2011)	35(7)$^{\lambda}$	Delay of gratification in five domains: food; physical pleasures; social interactions; money and achievement.	**Persistence** (behaviour; attention control)$^{\Delta}$	α^{a}=.69-.90 r^{b}=.74-.90	CFA; CV; CC	r=-.28 (food domain subscale vs fizzy drinks) r=-.37 (food domain subscale vs fast food intake)
8b	**Food Craving Acceptance and action questionnaire** (Juarascio, Forman, Timko, Butryn, & Goodwin, 2011)	10	Psychological flexibility in obesogenic environment: acceptance vs control	**Persistence; Adjustment** (behaviour ; thoughts; attention; feeling control)	α^{a}=.93 α^{b}=.72-.78	PCA; CV; DS	r=-.37 (food responsiveness vs FCAAC) r=-.22 (BMI vs FCAAC)
9b	**Weight Control Strategies Scale** (Pinto, Fava, Raynor, LaRose, & Wing, 2013)	30	Behavioural skills; healthy dietary and physical activity strategies; psychological coping skills; rewarding;	**Goal setting; Planning; Self-monitoring; Adjustment; Evaluation** (environmental control; behavioural; thoughts control)	α^{a}=.79-.89	PCA; CV	r=-.28 (weight vs WCSS) r=-.24 (Energy intake vs Dietary choices subscale) r=-.27 (Fat intake vs Dietary choices subscale)
10b	**Behavioural strategies to control the amount of food selected and consumed** (Poelman, de Vet, Velema, Seidell, & Steenhuis, 2014)	32	Behavioural strategies to cope with this environment to control the amount of food consumed	**Goal setting; Planning** (behaviour, environmental, attention control)	α^{a}=.82	CV	BMI was not significantly related to the use of the strategies, but it discriminate normal weight from overweight (p<.001)
11b	**Tempest Self-Regulation Questionnaire for Eating** (De Vet et al., 2014)	24	Strategies directly addressing the temptation; changing meaning of temptations; addressing goals	**Goal setting; Planning** (behaviour, attention; thoughts; feeling; environmental control	α^{a}=.73-.78 α^{b}=.80	PCA; CV; DS; CC	r=-.29 (SR vs snack intake) r=-.25 (SR vs soft drink intake) r=.30 (SR vs fruit intake) r=.21 (SR vs vegetable intake)

Note= ^Number of items of the Short version scale. $^{\lambda}$Number of items of the food/dieting domain scale. CV=Convergent validity. CC=Concurrent validity. DS= Discriminant validity. PCA= Principal Component Analysis. CFA=Confirmatory Factor Analysis. α^{a}= Internal reliability Cronbach's alpha. α^{b}=Test-retest reliability. r^{b}=Test-retest reliability Pearson's Correlation. r IT= Item-total correlation. r=Pearson's or Spearman's correlations $^{\Delta}$ Only related to the food domain

Tables 4.1 and 4.2 show that all the existing self-regulatory scales have been assessed for their internal reliability and results were adequate in most cases, with the exception of three eating-specific scales (1b; 2b & 7b) that showed low internal reliability ($\alpha<0.70$). On the other hand, external reliability was only evaluated for eleven scales out of 23, showing unsatisfactory results for two general self-regulatory scales (8a & 9a) and two eating-specific scales (2b & 5b). Although all of the scales have been tested for at least one type of validity, none seemed to have undergone all the relevant reliability and validity tests, such as internal and external reliability, PCA, CFA and construct validity.

The majority of the general measures of self-regulation have not been validated against healthy dietary and weight outcomes, and conflicting results were found among those which assessed their validity against alcohol intake (4a; 6a; 7a; 10a & 11a) and weight management (2a; 9a & 10a). This is in line with the literature reviewed in Chapter 2, which showed that general self-regulatory skills seem to be inappropriate for assessing self-regulatory skills related to healthy eating and weight.

With respect to eating-specific scales, a small and positive correlation was found between self-regulatory skills and healthy dietary behaviours in most validation studies (5b; 7b; 9b & 11b). However, conflicting results were found for the relationship between weight and eating self-regulation (2b; 3b; 5b; 8b; 9b & 10b). This may be a consequence of the inclusion of items assessing self-regulatory strategies for weight loss, which may be more relevant for people who are currently trying to lose weight, rather than those who want to maintain a healthy weight or do not have weight problems.

In terms of content, most of the self-regulatory scales also included items related to other constructs, such as self-efficacy; habits; appetitive traits, disinhibition and social support. Although it was possible to identify items assessing most of the processes and underlying abilities for self-regulatory actions as presented in Chapter 1, no scale assessing these processes and abilities uniquely related to eating behaviour was found. This confirmed the need for a new scale on eating self-regulatory skills that is valid and reliable.

4.3.1.2 Item Generation Study

Aim

The aim of this study was to generate items to assess all the abilities and processes of self-regulation of eating behaviour.

Method

Items were generated based on i) A review of the literature on self-regulation of eating behaviour theory (Chapter 1); ii) Existing questionnaires on self-regulation (Section 4.3.1.1); and iii) Input from experts in the field (All my supervisors). Criteria for inclusion of items in the item pool was that items should assess one of the key components of the self-regulation process (setting goals, self-monitoring, appraising progress, adjustments) and/or address the main abilities of self-regulation (behaviour, attention, affective and cognitive control).

Results

An initial large pool of 102 items was generated. Positively and negatively worded items were included to avoid 'response bias'. The response scale format chosen for the questionnaire was a 5-point Likert scale from never to always. Three screening questions were included at the beginning of the questionnaire, to allow only people who have the intention to either have a healthy diet or not to eat much of foods they find tempting to answer the SREBQ (see Appendix 4.4). These screening questions were worded to fit both people who want to achieve a healthy diet and those who have achieved a healthy diet and want to maintain it. General terms such as *'tempting foods'* were used throughout the questionnaire to enable people to respond to the questionnaire relative to their own eating intentions. The first pool of 102 items was reduced to 64 items after the first examination by the research team, based on the criteria of relevance, clarity and content.

4.3.1.3 Pilot study 1

Aim

The aim of this first pilot was to assess whether the items were easy to answer, unambiguous, and adequate and also to generate new items.

Participants

This study was conducted with an opportunistic sample of students and staff from University College London (UCL), who were aged 18 years or older (Sample 1).

Measures and procedure

Participants answered the 64-item questionnaire alongside open and closed questions about whether they actually define eating goals for themselves and whether they can identify them and reflect on them (see Appendix 4.4). They were also invited to assess the items and make comments if they wanted.

Analysis

Open ended answers were entered into an Excel spreadsheet and analysed qualitatively.

Results

A total of 20 students and staff (60% female) took part in the study. Answers to the open and closed questions around eating goals revealed that most participants reported defining their goals (85%), but these goals varied in terms of level of abstraction, type of food, and timeline. Items related to very specific goals were removed, for example *'How often do you plan to bring a piece of fruit to work every* *day?'.* Other items were removed because they repeated the screening questions, (e.g. *'how often do you set goals to eat healthily?'*), or were too similar to other questions. This resulted in the deletion of 22 items, generation of 15 new items and wording modifications to both the items and screening questions.

4.3.1.4 Pilot study 2

Aim

The aim of this second pilot was to assess the adequacy of the remaining items and to design new items.

Participants

This second pilot study used a larger and more varied convenience sample (Sample 2), compared to the first pilot. Participants were recruited from two different sources. All members of the charity Weight Concern's 'Big Panel' (an online panel of 1800 people who have a history of overweight or obesity), together with a wider sample of UCL staff and students were invited to participate via email. All participants were 18 years or over and no incentives were offered.

Measures and procedure

The remaining 57 items were administered using an online survey platform (https://www.surveymonkey.com.uk/). The survey was anonymous and participants were asked to answer the SREBQ and report their age, gender, weight and height (see Appendix 4.5). Open and closed questions were also included to assess participants' eating goals, and perceptions of the relevance and adequacy of the items.

Analysis

Descriptive analyses were carried out for the closed questions and qualitative analyses for the open questions. Items which were positively and strongly correlated with BMI were also deleted as the SREBQ aims to assess eating self-regulatory skills associated with successful weight control. Item analyses, such as corrected item-total correlation and item-item correlation were used to cull less useful items. Item-total correlation assesses the homogeneity of the scale. It correlates the score for an individual item with the total score for the scale. To avoid artificially inflated correlations, the result is corrected by removing the item score from the total score. Items which had corrected item-total correlation lower than 0.3 were removed (Field, 2013). Item-item correlation identifies items that do not correlate very well with the other items in the scale. Items were removed when more than 60% of the item-item correlation coefficients were lower than 0.3 (Streiner & Norman, 2008). All the psychometric and descriptive analyses were performed using IBM SPSS statistics version 22 (SPSS Inc., Chicago, IL, USA).

Results

In total, 309 individuals accessed the questionnaire online, but only 193 adults completed the entire questionnaire and were included in the analyses. Of these, 77% were women; 41.7% were normal weight, 15.6% were underweight, 17.7% were overweight and 25% were obese. The mean age was 40 years (sd 13.7). The majority of participants (79%) could identify eating goals they set for themselves. However, similar to the results from pilot study 1, participants' goals varied in terms of level of abstraction, type of food and timeline (see Table 4.3).

Table 4.3 Illustrative example of participants' eating goals in the pilot study 2

Topic	Eating goals' examples	Timescales' examples
Fruit and vegetables	"Eat fruits/vegetables"	"2 to 3 times a day"
	"Eat more veg"	"Long term"
	"Eat more fruit and vegetables and less carbs and very fatty foods"	"Continuous goals"
Snacking	"Not to snack on cakes and baked goods during working hours. I buy lots of fruit instead to prevent me from getting hungry"	"Continuous goals"
	"No snacking in between meals. Sometimes to not eat after 5pm"	"Usually for a month"
	"Eat regular meals no snacking. Do not eat when stressed; look for other solutions"	"Every day"
Weight loss programmes	"To follow Weight watchers programme"	"Longer"
	"Not exactly the 5:2 diet but something like it"	"one week"
	"Stick to slimming world plan"	"Longer"
Tempting foods	"Avoid eating foods high in carbs and sugar (cakes, biscuits, sweets, rice pasta, pizza pastries, bread)"	"Day"
	"Reduce sweet food"	"I don't have a time scale, just trying to"
	"Stop eating sugar; eat more fruit and veg; and stay out of the work cake tin"	"Lifetime"
	"Try and drink less coke. Less takeaways. Drink less alcohol"	"Long term goals, viewed over weekly time scale."
Portion size	"Eat smaller portions"	"Month"
	"Smaller portions"	"For ever"
	"I should eat smaller meals more frequently to avoid getting hungry"	"Every day"
Weight loss	"Loose 15Kg"	"8 months"
	"To move from being obese to a more healthy weight"	"18 months"
	"Calorie control. Max calories = 1300 on 9-5 days Max calories on night shift = 900 with no food after 1900 hrs This equals 1-2 ib loss per week"	"Until weight goal is achieved"
Healthy food	"To keep to a healthy eating plan and exercise"	"A week"
	"Eat red meat occasionally. Eat plenty of complex carbohydrates. Eat plenty of fruit and vegetables. Eat fish and chips occasionally, and seek good quality"	"Lifetime"
	"To eat only healthy foods"	"Life goals"
	"To eat healthier and not to overeat"	"As long as possible"
Other goals	"I don't eat dairy; I rarely eat meat if i do it's organic and free range; I never eat processed foods"	"For ever"
	"Stop drinking coffee"	"Longer"
	"Eat more calcium rich food"	"Month"
	"keep a food diary and weigh myself"	" Every day"

Note= This is only a sample of the eating goals found in the pilot study 2.

These results strengthened our decision to use general terms in the items, such as '*eating intentions'* and *'tempting foods'*, as this allows people to relate items to their personal goals. About 56% of the participants answered that there are other things they usually do to control their eating. The topic most mentioned was physical activity (see Table 4.4), followed by specific strategies for controlling their diet. However, as the questionnaire was intended to be solely related to the ability to regulate eating behaviours, no item related to physical activity nor specific strategies were included. The items in the SREBQ should assess whether people set specific plans and strategies to achieve their goals, but not what the strategies are, as these tend to vary from person to person.

Table 4.4 Illustrative example of other things participants from pilot study 2 usually do to control their eating

Topic	Examples of other things the participants do to control their eating
Physical activity	"Do as much exercises as possible"
	"Go for a walk and go for a swim"
	"Try to do some sports activities...but it is hard"
	"Exercise, it makes me consider more carefully what I am going to eat because I don't want to through away the work done at the gym"
	"Physical exercise - lots of it"
	"Keep busy and exercise"
	"Running 5K twice in the week, and 10-16K at weekends"
Strategies	"Don't eat in front of people; don't buy ""bad"" food; and avoid going out if it involves eating"
	"Try to keep to Weight watchers points"
	"Don't buy certain foods"
	"I have started the milkshake diet - I am also including fruit + veg"
	"Cook every evening for tomorrow lunch; do sports; and weak up in time"
	"Drink a cup of tea instead of snack on biscuits"
	"I find it helps with motivational posters/images/objects, whether they are some self-help mantra, or looking at summer plans for next year, or having a dress hanging in the closet I don't feel confident enough to wear yet."
	"No food after 8 pm"
	"Drinking coffee to suppress appetite"

Note= This is only a sample of other things the participants do to control their eating found in the pilot study 2.

Seventy one percent of the participants found the questionnaire easy and only 1 individual (0.5%) found the questions offensive or displeasing. Around 60% of the participants felt the questionnaire was assessing self-regulation of eating behaviour adequately. On the basis of the item-total correlation and item-item correlations and strong, positive associations with BMI, a total of 28 items were removed. The 29 items left were reworded and two new items were generated. For consistency all items using the term '*eating goals'* were reworded to *'eating intentions'*. Additionally, an explanation was provided at the beginning of the questionnaire stating that *'Eating intentions refer to the way you intend to eat (e.g. avoiding tempting foods and/or eating healthily)'.* The screening questions were also reworded.

4.3.1.5 Internal reliability and Initial Factor Structure Study

Aim

The aim of this cross-sectional study was to investigate the underlying structure of the draft SREBQ and explore its internal reliability.

Participants

Participants for this study were students and staff from UCL and members of 5 UK Facebook groups dedicated to discussion about weight loss and nutrition (Sample 3). Recruitment was via email and announcements posted on the groups' Facebook pages, with potential participants provided with a link for online completion of the survey. Participants were eligible for the study if they were aged 18 years or older; were living in the UK; had not taken part in the pilot studies and reported having eating intentions. All participants were invited to enter a prize draw for a £25 high street voucher.

Measures and procedure

The online survey was anonymous and administered using the Survey Monkey platform (https://www.surveymonkey.com/). It comprised the 31-item SREBQ, and questions on age, gender, weight and height (see Appendix 4.6). No questions on socio-demographic information were asked.

Analysis

Prior to factor structure analysis the scale was further refined in order to reduce item redundancy. Pairs of items with intra-item correlations greater than 0.6 (Streiner & Norman, 2008) were identified and one of each pair of items was removed. The refinement criteria to choose one item in each pair were the same as those used in pilot study 2.

The factor structure of the scale was determined by running Principal Component Analysis (PCA), which is a statistical technique used to reduce a set of variables into a smaller set of components[7] (Field, 2013). The idea behind this technique is to explain a group of items in terms of smaller unobserved factors (Dugard, Todman, & Staines, 2010). The PCA gives initial evidence for internal construct validity, which should be considered adequate when it provides meaningful components supported by the literature (Hobart, Riazi, Lamping, Fitzpatrick, & Thompson, 2004). PCA identifies the underlying components within a scale based on the variance (Ferguson & Cox, 1993) and it is usually performed with rotation of factors, as it facilitates the interpretation of the factor loading[8] results (Rattray & Jones, 2007). There are two possible factor rotations: orthogonal and oblique. The latter is usually used when factors should be correlated with each other and the former is used when factors should be independent (Ferguson & Cox, 1993; Field, 2013). As the components were expected to be correlated, a PCA with oblique rotation was chosen. To undertake factor structure analysis a sufficient sample size is required[9]. The Kaiser-Meyer-Olkin (KMO), which indicates whether the sample has a correlation matrix appropriate for the analysis of the factor structure, gives an idea about the adequacy of the sample size. A KMO should be ≥ 0.5 to be considered acceptable (Field, 2013). The Bartlett Test Sphericity (BS) assumption, which indicates whether the

[7] Throughout this thesis the terms 'factors' and 'components' are used interchangeably to refer to the grouping of items which describe a certain type of skill measured by the questionnaire.

[8] Factor loading represents the strength of relationship between a variable and a given factor or component and ranges from -1 to +1.

[9] A rule of thumb would be 10-15 individuals per item, however Field (2013) argues that the overall size of the sample is what matters. According to Ferguson and Cox (1993) a sample of at least 100 participants is required. On the other hand, Field (2013) suggests a sample of around 300 participants and Comrey and Lee (as cited in Field, 2013) classify a sample size of 1000 as excellent, 300 as good and 100 as poor.

correlations between items are overall significantly different than zero, should also be assessed (Field, 2013). However, large sample sizes tend to present significant BS results (Field, 2013). Multiple criteria were used to define how many factors should be extracted: Kaiser's criterion of eigenvalues[10] greater than 1; scree plot's point of inflexion[11] and factor loadings greater than 0.4 (Field, 2013; Hobart et al., 2004). Parallel analyses were also performed to help with the decision about the number of factors to retain.

PCA is also part of the refinement process for new scales. Therefore, items that had a factor loading greater than 0.4 on more than one factor, as well as items that failed to load above 0.39 on one factor, were removed (Field, 2013; Hobart et al., 2004). To reduce participant burden and enhance the utility of the scale, the content and psychometrics of the retained items were reassessed, and items were removed where multiple items measured the same aspects of self-regulation. Following the refinement process, the PCA was re-examined.

The Cronbach's alpha for the final scale was calculated, which should be ≥0.7 (Field, 2013). The Cronbach's alpha test measures how well interrelated the items are (internal consistency), based on the average correlation between all possible combinations of two sets of items. As it takes the number of items into account, the higher the number of items, the greater the internal reliability (Hobart et al., 2004). All the psychometric and descriptive analyses were performed using IBM SPSS statistics version 22 (SPSS Inc., Chicago, IL, USA).

Results

A total of 271 eligible participants completed the questionnaire and were included in the analysis. The majority were female (76.4%) and the mean age was 31.5 years (sd 12). In terms of weight status, 8.4% of the participants were underweight, 69.2% were normal weight; 18.1% overweight and 4.2% were obese. The initial refinement analyses removed 17 items. The PCA results for the 14 remaining items revealed a

[10]Eigenvalues are a measure of variance explained by the component (Ferguson & Cox, 1993).

[11]Scree plot is a graphic representation of the variance explained by the components (Ferguson & Cox, 1993).

one-factor solution based on the Scree Plot and the parallel analysis (see Appendix 4.7). All items had a factor loading greater than 0.4. However, content analyses of the remaining items indicated that there was still some redundancy and a total of 9 items were removed.

The PCA was run a second time on the final 5-item questionnaire and produced a one-factor solution (see Appendix 4.8), accounting for 51.4% of the variance (see Table 4.5). BS was statistically significant; however as the sample was large this was expected. A KMO of 0.8 suggested the sample size was adequate. The Cronbach's alpha coefficient for the 5-item questionnaire was 0.75. Corrected item-total correlations ranged from 0.42 to 0.61 and item-item correlations from 0.25 to 0.54.

Table 4.5 Factor structure of the 5-item SREBQ

Item	Factor loading	Ability/ Processes
I'm good at resisting tempting food	.797	Ability to control behaviour, thoughts, feeling, attention and eat in accordance with your intentions/ short-term ability to regulate eating behaviours
I give up too easily on my eating intentions^{R}	.789	Ability to stick to your eating intentions and continuously work toward them/ long-term ability to self-regulate eating behaviours
I easily get distracted from my eating intentions^{R}	.746	Ability to control thoughts and attention and keep your eating goals in mind
I find it hard to remember what I have eaten throughout the day^{R}	.618	Ability to monitor and be aware of your actual eating behaviour
If I am not eating in the way I intend to I make changes	.612	Ability to compare your actual behaviour to your eating intentions (reference) and make adjustments when necessary to achieve your intentions

Note= Response scale for each item ranged from 1 (Never),to 5 (Always). ^{R}Reverse item. Variance explained: 51.4%. KMO=0.80. Item-item correlation (range): 0.25 to 0.54. Item-total correlation (range):0.42 to 0.61.

The final 5-item SREBQ included the main components of the self-regulation process (self-monitoring, appraising progress, making amendments, giving up). The items also encompassed the ability to control behaviour, thoughts and attention, supporting its content validity.

4.3.2 Reliability and Validity of the Self-regulation of Eating Behaviour Questionnaire Study

4.3.2.1 Aim

This cross-sectional study aimed to assess the construct validity of the SREBQ by confirming its final 5-item structure, as well as the concurrent, convergent, and discriminant validities of the questionnaire. This study also aimed to assess the test-retest and confirm the questionnaire's internal reliability.

In order to assess the convergent validity of the SREBQ, hypotheses were generated for the relationships between the SREBQ scores and other related variables. Positive relationships between SREBQ and fruit and vegetable intake, level of motivation and automaticity were expected. SREBQ scores were also expected to be negatively related to Body Mass Index (BMI), sweet and salty snacks intake, sugary drinks intake, food responsiveness and emotional overeating. With respect to the discriminant validity, weak relationships were hypothesized between SREBQ score and scores for food fussiness, satiety responsiveness and slowness in eating. Regarding the concurrent validity, medium-sized correlations between the SREBQ score and the score of other established questionnaires of self-regulation were expected.

4.3.2.2 Participants

The fourth sample was recruited through Research Now, an online market research company, which has access to a panel of over 6,000,000 UK residents and offers a small cash incentive for participation. A sample of 1000 is recommended by Comrey and Lee (as cited in Field, 2013) as ideal for validation studies, so 1000 adults aged between 20 to 65 years living in the UK were recruited to the validation study and a second response was obtained from 100 participants for the test-retest study. In order to obtain a more representative sample, criteria for gender (50% Male); and weight status (55-60% overweight or obese) were established. Weight status percentages were established based on weight status statistics for the UK adult population (England, 2012). To fulfil the required weight profile of the participants, age quotas (see Table 4.6) were established based on the percentages of overweight and obese obtained per age group in a previous study conducted by our research group (Hunot et al., 2016). This previous study collected data on eating behaviours and weight control using the same pool of panellists from the Research Now Company. Participants with a BMI lower than 14kg/m^2 or greater than 50 kg/m^2 were excluded, as these values were considered too extreme and may represent unreliable self-reports of weight or height.

Table 4.6 Age and weight categories used to select quotas of participants

Age ranges	**Results from the Adults' eating behaviours and weight control study***			**Quotas of participants for the present study**		
		Normal weight	**Overweight/ obese**		**Normal weight expected**	**Overweight/ obese expected**
	N	N(%)	N(%)	N	N(%)	N(%)
20 to 29 years	176	106(60)	70(40)	200	120(60)	80(40)
30 to 39 years	92	41(44)	51(56)	200	88(44)	112(56)
40 to 49 years	89	37(41)	52(59)	250	102(41)	148(59)
50 to 59 years	88	37(42)	51(58)	250	105(42)	145(58)
60 to 65 years	93	36(39)	57(61)	100	39(39)	61(61)
Total	538	257(48)	281(52)	1000	454(45)	546(55)

Note= *Data from Hunot et al. (2016).

4.3.2.3 Procedure

This study received ethical approval (ID 5766/002) from the University College London Ethics Committee (See Appendix 4.9). Panellists were invited via e-mail to complete the survey online (See Appendix 4.10). All participants gave informed consent. Only participants who intended to control their consumption of foods they find tempting or have a healthy diet completed the SREBQ. Panellists who did not have either of these intentions were ineligible, as the items assume people have eating intentions. The survey was found to take around 25 minutes and participants had one week to complete it. Responses completed in 14 minutes or less were discarded, as this would not have allowed sufficient time for participants to read and complete the survey. Surveys with the same answer for all items were also removed.

To test the external (test-retest) reliability of the SREBQ, the first 200 respondents were re-contacted 2 weeks later and asked to complete only the SREBQ again. Two weeks is considered to be an acceptable length of time for participants not to be likely to remember their original responses exactly, nor to have had any notable changes in their level of self-regulation. Recruitment for the test-retest was closed when the required sample size of 100 was reached. First and second time responses were matched using panellists ID numbers.

4.3.2.4 Measures

The survey was administered using an online survey platform (https://www.surveymonkey.com/). Participants completed the 5-item SREBQ and were asked to report their weight and height; gender; age; ethnicity; marital status; postcode; education; employment status and living arrangements. The socio-demographic questions were constructed based on the Census Questionnaire for England 2011(Office for National Statistics, 2011) and on the socio-demographic questions designed for the English Longitudinal Study of Aging (Gjonça & Calderwood, 2004).

To assess dietary intake, participants answered a valid 2-item fruit and vegetable intake scale (Cappuccio et al., 2003). Respondents reported the frequency they eat these foods on a 7-point response scale that ranged from 1 (less than once a week) to 7 (three or more a day). Following the adaptations made to this scale by Croker, Lucas, and Wardle (2012) in a study conducted with parents, two other items were included, one assessing the frequency of sweets and salty snacks (SSS) intake, and the other one assessing the frequency of sugary drinks (SD) intake. Also, following McGowan, Croker, Wardle, and Cooke (2012), answers were recoded to represent daily intake, for example, ‘2-3 times a week’ was coded as 0.36.

To enable assessment of the concurrent validity of the questionnaire, participants had to answer questions from 2 validated self-regulation questionnaires; the Perceived Self-Regulatory Success in Dieting Scale (PSRSDS) and the Brief Self-Control Scale (SCS). The PSRSDS is a 3-item questionnaire measuring how successful people are at dieting (Meule et al., 2012). Participants rate on a 7-point scale how successful they are at watching their weight and losing weight, and also how difficult they find it to maintain their weight. The brief SCS is a 13-item scale measuring individual differences in general self-control (Tangney et al., 2004). The scale was designed to assess the ability to break habits, resist temptations and maintain self-discipline. Participants were asked to answer on a 5-point response scale how well the items described them.

Regarding the convergent validity of the SREBQ, participants were asked to answer other validated questionnaires for constructs likely to be related to eating self-regulatory skills. They answered the autonomous motivation subscale of the Dietary Self-Regulation Questionnaire, a 3-item sub-scale assessing the level of motivation to either start eating healthily or to continue to do so by rating on a 5-point scale their reasons for eating a healthy diet (Levesque et al., 2007). Participants also answered the Self-Report Habit Index, a 12-item scale (Verplanken & Orbell, 2003), assessing the automaticity of avoiding tempting food on a 5-point response scale. In addition, respondents answered 2 subscales from the Adult Eating Behaviour Questionnaire (AEBQ), an adapted and validated version of the Child Eating Behaviour Questionnaire (Hunot et al., 2016; Wardle, Guthrie, Sanderson, & Rapoport, 2001), which measures a set of appetitive traits that confer risk of obesity. These were the four-item Food Responsiveness subscale, assessing interest in food and drive to eat, and the five-item Emotional Over-eating subscale, assessing the tendency to overeat in negative emotional states.

In order to assess the discriminant validity, participants were required to answer another 3 subscales from the AEBQ, which are related to better biological self-regulation, and therefore should not be related to intentional self-regulation. These were the 4-item Satiety Responsiveness subscale, measuring the individual's sensitivity to fullness, the 5-item Food Fussiness subscale, and the 4-item Slowness in Eating subscale.

4.3.2.5 Statistical analyses

Having established the SREBQ's single factor structure in the previous study, a Confirmatory Factor Analysis (CFA) was performed to confirm this structure, providing evidence for its internal construct validity (Hobart et al., 2004). CFA is the measurement modelling component of a broader approach called Structural Equation Modelling (Dugard et al., 2010). CFA allows specification of the exact model, and then tests the data against this model (Ferguson & Cox, 1993). CFA also allows modifications to the model to be set, using the modification indices. However, this can compromise the validity of the model (Dugard et al., 2010). The CFA is specified using a diagram, where the factors are presented as circles and the measured variables[12] as rectangles. It displays regression coefficients, which represent the influence of the factors on the measured variables and also the R^2 which represents how much of the variance on the measured variable can be explained by the factor (Dugard et al., 2010). Regression coefficients can be interpreted as 'factor loadings' and are recommended to be greater than 0.3 (Moilanen, 2006). CFA also displays the covariance between the factors, to explain their relationship without giving any direction of effect. There should always be two arrows pointing to each measured variable and they indicate the influence of the factor and of the 'error' on the measured variable (Dugard et al., 2010). It is recommended to consult several goodness of fit statistics in order to assess whether the results are similar and judge if the model fits the data (Thompson, 2004). The indices most commonly used are the Chi-square, which should be non-significant. However, Chi-square very readily reaches significance with large sample sizes even when all other indices indicate a good fit (Dugard et al, 2010). The minimum requirements for the other indices are: Normed Fit Index (NFI) and Comparative Fit Index (CFI) should be close to 1 (Dugard et al., 2010), which represents how much the model improves the fit relative to the null model, (e.g. 0.9 would represent 90% of improvement). The Root-Mean-Square Error Approximation (RMSEA) represents a bad fit when greater than 0.1 (Dugard et al., 2010).

[12] Measured variables are variables for which we have data (observations in our dataset).

The other forms of validity measured in this study were concurrent, convergent and discriminant validities. Concurrent validity involves the administration at the same time of the new measure and an old and valid measure of the same construct widely used in the literature (Streiner & Norman, 2008). Thus, the SREBQ scores were tested against the scores for a general self-regulation measure (Self-Control Scale) and also against scores for a measure of perceived successful dietary self-regulation (Perceived Self-Regulatory Success in Dieting Scale). Pearson's correlations were applied, as the sample was shown to be normally distributed after plotting histograms and P-Plots and also looking at the distribution of the variables, such as measures of central tendency, variability and shape. The second type of validity was convergent validity, which is an approach that assesses whether the new scale is related to other variables to which it should be related to (Streiner & Norman, 2008). To evaluate the convergent validity, relationships between SREBQ and BMI; F&V intake; SSS intake; SD intake; autonomous motivation; automaticity; food responsiveness; and emotional over-eating were assessed. BMI was calculated by dividing individuals' weight (kilograms) by the square of their height (metres). Pearson's correlations were performed as the sample was shown to be normally distributed. Multiple regression analysis were performed to examine the independent contribution of each of these variables to SREBQ scores. Residuals were examined for all outcomes and approximated normal distribution in all cases. The presence of outliers was also checked, but because the results were not sensitive to their inclusion or exclusion, we used the full sample. The third type of validity was discriminant validity, which assesses whether the new scale is not related to other measures to which it should not be related to (Streiner & Norman, 2008). Pearson's correlations were performed between the SREBQ and satiety responsiveness, sensitivity to fullness, food fussiness and slowness in eating.

The SREBQ had its internal reliability re-examined, including the assessment of the corrected item-total correlation and the Cronbach's alpha. An external reliability (test-retest) approach was used to test the reliability of the questionnaire over time. This test aims to assess whether the scale obtains similar results on repeated measurements (Hobart et al., 2004). Paired t-tests and Intraclass Correlation

Coefficients (ICC) were calculated for the overall score. The minimum requirement for ICC is that it should be >0.7.

All analyses were performed using IBM SPSS statistics version 22 (SPSS Inc., Chicago, IL, USA), except the CFA, which was performed using AMOS SPSS version 22 (SPSS Inc., Chicago, IL, USA). Descriptive analyses were performed to characterise the sample. Statistical significance was defined as a value of $p \leq 0.05$.

4.3.2.6 Results

A total of 1000 responses were obtained from the Research Now Panel. After quality checks, including time taken and pattern of responses, 46 responses were excluded. Thirty-one participants with missing data for the SREBQ were also omitted from the analysis, resulting in a final sample of 923 participants. For the test-retest 100 completed responses were obtained. The characteristics of the participants for both samples are presented in Table 4.7.

Table 4.7 Characteristics of the samples

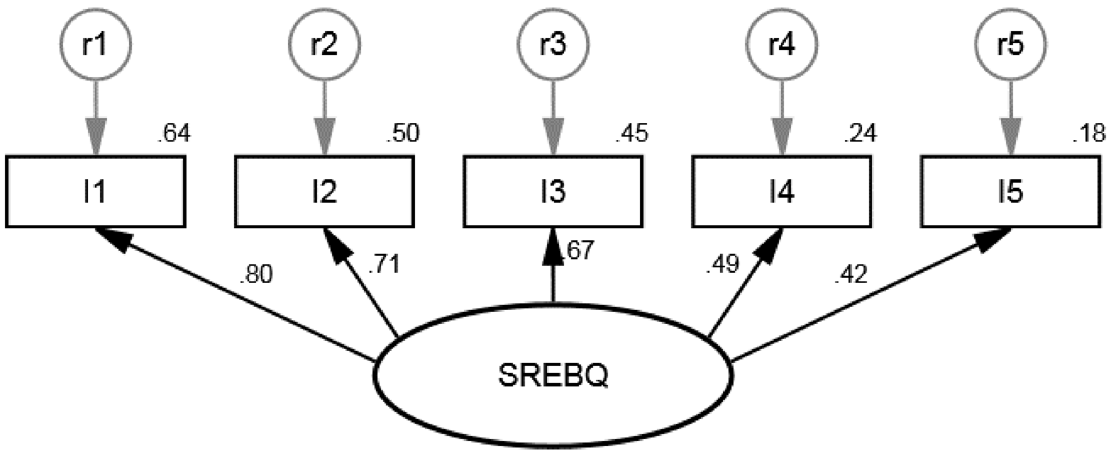
Variable	Total sample (N=923) N	Total sample (N=923) %	Test-retest sample (N=100) N	Test-retest sample (N=100) %
Gender				
Female	535	58	82	82
Male	388	42	18	18
Age				
20 to 29 years old	155	17	13	13
30 to 39 years old	167	18	17	17
40 to 49 years old	231	25	20	20
50 to 59 years old	238	26	24	24
60 to 65 years old	132	14	26	26
Ethnic group				
White	837	91	93	93
Black	20	2	1	1
Asian	40	4	3	3
Mixed	15	2	0	0
Other	11	1	3	3
Marital status				
Single	235	25	23	23
Married[a]	590	64	64	64
Separated/ Widowed[b]	98	11	13	13
Education				
Primary/secondary school	79	9	13	13
O level to A levels[c]	289	31	37	37
Certificate/ Diploma[d]	212	23	18	18
Degree[e]	343	37	32	32
Employment situation				
Paid work[f]	567	61	54	54
Unpaid work/ unemployed[g]	210	23	24	24
Student	40	4	4	4
Retired	106	12	18	18
Living arrangement				
Own your home[h]	537	58	66	66
Renting[i]	312	34	30	30
Living with parents/University halls[j]	74	8	4	4
Weight status				
Underweight[k]	23	3	4	4
Normal weight[l]	363	39	43	43
Overweight[m]	273	30	24	24
Obese[n]	250	27	27	27
Missing[o]	14	1	2	2

Note= [a]Married or living as married. [b]Separated, divorced or widowed. [c]O level/ GCSEs/ A levels. [d]Technical or trade certificate/ Diploma. [e]Degree or Post-graduate degree. [f]Employed full-time/ Employed part-time/ Self-employed [g]Unemployed/ Full-time homemaker/ Unpaid or voluntary work/ Disable or too ill to work. [h]Own your home outright/ Own your home with mortgage. [i]Rent from local authority or housing association/ Rent privately. [j]Living with parents/ Living in University or College halls. [k]BMI from 14 to 18.49 Kg/m^2. [l]BMI from 18.5 to 24.99 Kg/m^2. [m]BMI from 25 to 29.99 Kg/m^2. [n]BMI from 30 to 50 Kg/m^2. [o]Missing data includes: 2 participants with no data; 10 participants with BMI greater than 50 Kg/m^2 and 2 participants with BMI lower than 14 Kg/m^2.

The final sample of 923 participants met the requirement of roughly equal numbers of male vs. female (42% vs 58%) and an age group balance. The sample also met the weight status requirement: 57% of participants were overweight or obese and 39% were normal weight. The majority of participants were white (91%), married (64%); employed (61%); and owned their own home (58%). Around one third reported their highest education to be O levels to A levels (31%), and just over one third had a degree (37%). The test-retest sample was similar to the main sample, except for gender, with the majority of participants for the test-retest female (82%).

Figure 4.2 shows the results for the CFA. The Chi-square results were significant (*df*=5; x^2=29.400; p<0.001). However, other model fit indices showed a good fit: NFI= 0.97; CFI= 0.97; TLI= 0.93 and RMSEA= 0.07. All the regression coefficients were greater than 0.4 and no modifications to the model were performed, demonstrating that the model fitted the data.

Figure 4.2 Final one-factor confirmatory factor analysis model for the SREBQ (N=923)



Note= Values over the arrow are the regression coefficients (Beta values). Values over the observed variables are the R^2.

Correlations between the SREBQ and other measures of self-regulation are presented in Table 4.8. SREBQ scores had a medium and positive correlation with the overall scores for the PSRSDS and the SCS. In terms of the convergent validity, the SREBQ showed a small and positive correlation with F&V intake; a small and negative correlation with SD consumption; and a medium and negative correlation with SSS intake. These dietary variables showed a stronger correlation with SREBQ than with the other measures of self-regulation. In terms of weight status, SREBQ scores had a small and negative correlation with BMI. This relationship was stronger than the correlation between SCS and BMI, but weaker than the correlation between PSSDS and BMI.

The SREBQ also showed a strong positive correlation with automaticity and a positive, but small correlation with autonomous motivation to have a healthy diet. In addition, the results showed a medium and negative correlation with food responsiveness and emotional over-eating. In terms of the discriminant validity, the results showed a very small and negative correlation with food fussiness and a very small and positive correlation with satiety responsiveness and slowness in eating.

Table 4.8 Concurrent, Convergent and Discriminant validity tests of the SREBQ (N=923)

	Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Concurrent validity															
1	SREBQ[a]														
2	PSRSDS[b]	.54**													
3	SCS[c]	.58**	.45**												
Convergent validity															
4	Fruit and vegetable intake	.30**	.22**	.27**											
5	Sweet and salty snack intake	-.40**	-.16**	-.26**	-0.02										
6	Sugary drinks intake	-.23**	-.10**	-.21**	-.24**	.34**									
7	Body Mass Index	-.28**	-.55**	-.21**	-.09**	0.05	.07*								
8	Automaticity of avoiding tempting food	.60**	.46**	.41**	.30**	-.29**	-.17**	-.26**							
9	Motivation to have a healthy diet	.23**	.15**	.19**	.34**	-.07*	-.15**	-.10**	.21**						
10	Food Responsiveness	-.40**	-.21**	-.41**	-.06	.26**	.07*	.09**	-.18**	-.03					
11	Emotional overeating	-.40**	-.37*	-.40**	-.06	.20**	.12**	.28**	-.19**	-.07*	.43**				
Discriminant validity															
12	Food Fussiness	-.14**	-.10**	-.09**	-.18**	.12**	.19**	.04	-.09**	-.15**	-.10**	.08*			
13	Satiety Responsiveness	.062	.11**	.07*	-.08*	-.05	.08**	-.13**	.18**	-.05	-.23**	-.13**	.20**		
14	Slowness in eating	.07*	.14**	.09**	-.02	-.037	.05	-.10**	.09**	-.06	-.20**	-.13**	.06	.46**	

Note= [a]SREBQ: Self-Regyulation of Eating Behaviour Questionnaire. [b]PSRSDS: Perceived Self-Regulatory Success in Dieting Scale. [c]SCS: Self-Control Scale.*p≤0.05 (2-tailed) ***p*<0.001 (2-tailed)

In order to see whether the convergent validity variables were independently associated with eating self-regulatory skills, when adjusting for socio-demographic variables, a hierarchical multiple regression analysis was run (see Table 4.9). Variables entered at the first stage were age and gender, followed by weight and dietary variables and then automaticity, motivation, food responsiveness and emotional overeating validity variables. The full model was statistically significant [$F(10, 889)=107.16$, $p<0.001$; R^2 adjusted=0.541] and accounted for 54.7% of the variance in SREBQ score. The addition of each block of independent variables led to a statistically significant increase in R^2 (See Table 4.9). The results for the full model showed that higher SREBQ score was predicted by lower BMI; SSS intake; food responsiveness; and emotional over-eating, and by higher F&V intake; automaticity of avoiding tempting food; and motivation to have a healthy diet. Only SD intake was not independently related to eating self-regulatory skills. Neither gender nor age significantly predicted eating self-regulatory skills.

Table 4.9 Multiple regression analyses for the SREBQ

Model	Variables	SREBQ mean score (Full model)			R^2 change	F statistic
		B	β	*p*		
1	Gender[a]	-.06	-.04	.052	.030	F(2,897)=13.6, *p*<0.001
	Age	.00	-.00	.841		
2	Body Mass Index	-.01	-.08	<.001	.295	F(4,893)=97.6, *p*<0.001
	Fruit and vegetable intake	.05	.13	<.001		
	Sweet and salty snacks intake	-.14	-.17	<.001		
	Sugary drinks intake	-.03	-.03	.250		
3	Automaticity of avoiding tempting foods.	.36	.40	<.001	.222	F(889,4)=108.6, *p*<0.001
	Autonomous motivation to have a healthy diet	.05	.06	.013		
	Food responsiveness	-.16	-.19	<.001		
	Emotional over-eating	-.10	-.16	<.001		

Note= Scores for self-regulation range from 1 to 5. [a]Male=0 and Female=1. SREBQ constant: 3.0 (0.164).

The corrected item-total correlation of SREBQ ranged from 0.36 to 0.65, and the Cronbach's alpha was 0.75. In terms of the test-retest results, the SREBQ showed an ICC of 0.77 (95%CI 0.67; 0.83) and the paired t-test was non-significant [t(99)=0.59; *p*=0.55].

4.4 Discussion

The aim of the present study was to design and validate a measure to assess eating-related self-regulatory skills. The content of the SREBQ was informed by examining the literature and existing questionnaires of self-regulation. The process of developing the SREBQ resulted in a 5-item questionnaire. The face validity was satisfactory and the factor structure analysis suggested that the questionnaire has one underlying factor. This structure was then tested in a different sample, and showed a good fit. Evidence for the construct validity of the SREBQ was demonstrated with tests of concurrent, convergent and discriminant validity.

Associations between the SREBQ and other measures of self-regulation were positive and represented a medium correlation, as expected (Streiner & Norman, 2008). The SREBQ was better at assessing self-regulatory skills related to eating a healthy diet than the SCS and PSRSDS. It was also better at assessing self-regulatory skills related to weight control than the SCS. However, as expected, the PSRSDS showed a stronger correlation with BMI than the SREBQ, since the PSRSDS assesses self-regulatory skills related specifically to weight control (Meule et al., 2012). The SREBQ showed sufficient uniqueness in terms of non-shared variance and was better at assessing self-regulation of eating behaviour than existing measures. The SREBQ's score was also associated with related constructs (Bargh & Williams, 2006; Hofmann, Schmeichel, et al., 2012a; Llewellyn & Wardle, 2015), such as automaticity, motivation for healthy diet, food responsiveness and emotional over-eating. Additionally, the SREBQ showed good discriminant validity, demonstrated by weak correlations with appetitive constructs thought to be biologically driven and therefore unrelated (Llewellyn & Wardle, 2015), such as satiety responsiveness, food fussiness and slowness in eating.

The Multiple Regression model showed that the variables demonstrating convergent validity explained more than 50% of the variance in the total score for the SREBQ. As anticipated, lower BMI, lower SSS intake, and higher F&V intake significantly predicted eating self-regulatory skills. The effect size was greater for SSS intake compared to the other diet variables. It has been suggested that 'positive' behaviours, such as the consumption of F&V, more easily become habitual through routine and repetition of the behaviour, reducing the need for effortful self-regulation. On the other hand inhibiting 'negative' behaviours, such as avoidance of unhealthy foods, may require cognitively-mediated self-regulatory skills to be maintained (Gardner, Lally, et al., 2012; Marteau et al., 2012). However, the relationship between self-regulatory skills and changes in the automaticity of dietary behaviours should be further investigated using longitudinal research designs. Further studies are also needed to clarify why the relationship between self-regulation and sugary drinks consumption was not significant after adjusting for the other variables. I hypothesize that other factors, such as nutrition knowledge may play a moderator role in the relationship between self-regulation and sugary drinks consumption.

In the Multiple Regression model, results for the related constructs automaticity and motivation showed a positive and significant relationship with self-regulatory skills, while food responsiveness and emotional over-eating showed a significant negative relationship. The effect size was stronger for automaticity and weaker for motivation. These results seem to be supported by the literature. According to the COM-B system, in order to change a behaviour, sufficient motivation, capacity and opportunity are required (Michie, van Stralen, & West, 2011). The reflective motivation assessed in this study involves effortful behavioural processes (Bandura, 2005), usually required during the process of behaviour change. Variance in reflective motivation resources may explain why some people experience self-regulatory failure during the behaviour change process (Muraven & Slessareva, 2003). As the individual achieves their intended behaviour, self-regulatory skills also becomes more automatic and efficient, requiring less reflective motivational resources (Bargh & Williams, 2006; Marteau et al., 2012).

Finally, the regression results showed that eating self-regulatory skills were not related to age or gender. Some studies have shown that self-regulation may have an inverted U-shaped association with age (Hippel & Henry, 2011; Williams, Ponesse, Schachar, Logan, & Tannock, 1999), increasing through adolescence and reducing in old age. The present study only included adults aged 20 to 65, and therefore no variation in self-regulation was expected. The gender results were also in accordance with the literature, as studies have shown that there are no significant differences in self-regulatory skills between men and women over the life span (Carey et al., 2004; Kolodziejczyk et al., 2015). The five-item SREBQ also showed good internal and external reliability demonstrating that the questionnaire is measuring eating self-regulatory skills consistently and reproducibly.

4.5 Study limitations

There are some limitations that may affect the generalizability of these results. The findings regarding the validity and reliability are limited to the population of this study and the use of only self-report questionnaire measures. Future studies are needed to test the validity of the SREBQ in different populations (e.g. ethnic minorities and other countries) and against behavioural measures, and to explore the SREBQ's predictive validity and responsiveness to change using longitudinal data. For convenience, university students and staff were invited to take part in the development process of the SREBQ and these are unlikely to reflect the educational and socio-economic status of the general population. However, the validity and reliability study included a more diverse sample of the UK population and found similar results. All data collection was online, which means that those without a computer or internet access were excluded. There is also no information about how many people actually received the invitation but chose not to participate in each study. People with a greater interest in nutrition and weight control may have been more likely to take part. The results from the correlations and multiple regression analyses came from a cross-sectional study, and so cannot demonstrate causality. Self-report of weight and height may have introduced some inaccuracy to this data. However, studies have shown that adults, especially young adults, give a valid online self-reported weight (Pursey, Burrows, Stanwell, & Collins, 2014).

4.6 Conclusions

The five-item SREBQ is a novel measure of eating self-regulatory skills that is consistent, reliable and valid for use in the general UK adult population. The validation process provided evidence that the SREBQ assesses people's ability to control and manage their eating behaviour in order to achieve and/or maintain their eating intentions. This new measure is likely to be useful for the assessment of the effectiveness of dietary and weight control interventions and particularly for assessing the effectiveness of interventions which aim to improve dietary self-regulation. Its brevity is also a strength, since it will be easy to be included in future observational and intervention studies without increasing participants' burden. Future studies should assess the relationships between self-regulation of eating behaviour, weight and diet using experimental and longitudinal study designs.

CHAPTER 5: RELATIONSHIPS BETWEEN EATING SELF-REGULATORY SKILLS, WEIGHT CONTROL AND DIETARY BEHAVIOURS IN FIRST YEAR UNDERGRADUATE STUDENTS (Study 2)[1]

5.1 Introduction

According to the previous chapter (Study 1), there is a need for studies assessing the relationships between eating self-regulatory skills, weight and diet using longitudinal designs. Conclusions from Chapter 1 suggest that self-regulatory skills may be important for helping people to maintain a healthy weight and diet. However, most of the studies presented in Chapter 2 looked at these relationships using cross-sectional data, and had not used a comprehensive and valid measure to assess eating self-regulatory skills (De Vet et al., 2014; de Wit et al., 2015; Jacobs & Wagner, 1984; Junger & van Kampen, 2010; Keller & Siegrist, 2015; Kennett & Nisbet, 1998; Kolodziejczyk et al., 2015; Schroder et al., 2013). Exploring whether the ability to regulate eating behaviours is a predictor of weight changes in first year undergraduate students could potentially address this issue, as there is consistent evidence showing that first year students are at risk of weight gain (Crombie, Ilich, Dutton, Panton, & Abood, 2009; Vella-Zarb & Elgar, 2009).

The transition to university is a period characterised by changes in lifestyles, environment and responsibilities. In the late 1990's, a belief that this period leads to dramatic weight gain, identified as the 'Freshman 15 pounds (6.8kg)' was widely spread by newspapers and academic articles (Brown, 2008; Graham & Jones, 2002). More recent studies have indicated a lower but still significant weight gain among students starting university (Crombie et al., 2009). According to a review and meta-analyses conducted by Vella-Zarb and Elgar (2009), students gain on average 1.75 kg (95%CI 1.73; 1.77) over the course of their first year. In agreement with this,

[1]A version of this chapter has been submitted to *Journal of the Academy of Nutrition and Dietetics*

a longitudinal online study collected self-reported weights and heights from 1225 British first year undergraduate students and found they gained on average 1.8 kg (sd 2.6) in their first 9 months of studies (Nikolaou, Hankey, & Lean, 2015).

However, the reasons for this vulnerability to weight gain are still unclear. According to two reviews, weight gain in first year undergraduate students seems to be associated with high baseline weight; dietary changes; decreases in physical activity; living in residential halls; level of stress, and dietary restraint (Crombie et al., 2009; Vella-Zarb & Elgar, 2009). Genetic influences may also play a role (Meisel, Beeken, van Jaarsveld, & Wardle, 2015). However, higher baseline weight is not always a predictor of weight gain. A study conducted with 120 first year students from 4 universities in the UK found that students with a lower baseline weight actually gained the most weight over a 12-month period (Finlayson, Cecil, Higgs, Hill, & Hetherington, 2012). Regarding the relationship between dietary changes and weight gain, a study with first year students from the United States found that weight gain in male students (N=140) was predicted by an increase in alcohol consumption whereas in female students (N=256) it was predicted by lower fruit and vegetable intake (Economos, Hildebrandt, & Hyatt, 2008). In contrast, some studies have found that dietary behaviours neither change nor predict weight gain in first year undergraduate students (Boyce & Kuijer, 2015; Nikolaou et al., 2015). These inconsistencies may be due to a lack of power to detect changes or because of the use of different measures to assess weight, physical activity and dietary behaviours.

With respect to dietary restraint and its relationship with weight gain, studies have also not shown consistent results. For example, Provencher et al. (2009) found in a cohort of first year students (N=2921) from 6 Canadian universities that high levels of dietary restraint were related to both weight loss and weight gain. As discussed in Chapter 1, this may be a consequence of the differences in the measures of restraint, as some of them assess a range of other constructs rather than restraint. Some authors have also argued that conflicting results may be due to the fact that some restrained dieters have higher eating self-regulatory skills than others (Johnson et al., 2012; Phelan et al., 2009). In concordance with this argument, a study showed that Dutch female undergraduate students (N=74; from any year) with a strong preference for unhealthy food and with low inhibition control gained the most weight over a year (Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010).

Eating self-regulatory skills may be required to keep healthy habits and/or build new ones due to disruptions of old habitual behaviours caused by the dramatic changes in routine, environment and social life experienced by students. The new environment may also increase demands on self-control to inhibit impulses towards food temptations, since students tend to experience a high exposure to unhealthy food options at university (Grech, Hebden, Roy, & Allman-Farinelli, 2016). Studies have consistently shown that higher self-control is related to greater ability to successfully regulate behaviour (Tangney et al., 2004) and lower likelihood of ego depletion (Muraven et al., 2005). Therefore, starting university with a high level of eating self-regulatory skills may be a protective factor against unhealthy changes in weight and diet.

5.2 Study aims and contribution to the literature

The aim of this study was to examine the relationships between eating self-regulatory skills, weight and dietary behaviours over 6 months in an online longitudinal cohort of undergraduate students from London, UK. This study hypothesised that high eating self-regulatory skills at baseline would prevent weight gain at 6-month follow-up. However, since small weight gains would not be meaningful and could be just a consequence of a natural weight fluctuation, this study also tested the hypothesis that high eating self-regulatory skills at baseline would protect against a substantial weight gain (≥5% initial body weight). Additionally, this study hypothesised that high eating self-regulatory skills at baseline would help people to achieve or maintain healthier dietary behaviours over the first 6 months at university. People who worsened their dietary behaviours and those who maintained an unhealthy diet over the first 6 months at university would have lower eating self-regulatory skills at baseline.

To our knowledge there is no study that has previously examined eating self-regulatory skills using a valid and reliable scale in this population. Results from this study may potentially give evidence for the impact of eating self-regulatory skills on weight and dietary behaviours and assist the design of appropriate interventions to prevent weight gain and promote healthy eating behaviours in this population.

5.3 Methods

5.3.1 Participants

Participants were first year undergraduate students (year 2015/16) from universities situated in London. Based on the list of 26 members of the Universities UK ("Universities UK," 2015) in London, 13 (50%) universities were chosen and invited to take part in the study. The choice criteria were convenience and having at least one university representing each of the 7 regions of London (see Appendix 5.1). Contact was initially made with all the faculties or schools within each university included in the study, but when no appropriate contact was found in the faculty or school, departments were contacted. The 13 universities contacted were as follows: London Metropolitan University; Middlesex University; Brunel University London; Birkbeck University; City University London; Imperial College London; SOAS, University of London; University College London; Westminster University; University of East London; Goldsmiths University; University of Greenwich and University of Roehampton. All interested students within these universities aged between 18 and 30 years who were able to give informed consent and accepted to complete the online survey twice over a 6 months period were eligible. Participants who were 30 years old or over were excluded, as older students might not be as susceptible to weight gain as younger students (Hulanicka & Kotlarz, 1983). Also, height growth tends to cease after 18 years old, however a final growth of an average of 2.13 cm can still be observed in males from 18 to 27 years old (Hulanicka & Kotlarz, 1983). So, a criterion for height changes was established allowing for reporting errors (+/- 1 cm), where participants with a height change ≤-1 or ≥4 cm were excluded from the analyses.

5.3.2 Sample size

A sample of at least 286 participants was aimed for to detect a medium effect (R^2=0.15) of eating self-regulatory skills on weight or dietary behaviours, when running multiple regression tests with up to 10 predictors (Field, 2013). The sample size calculation ensured 95% power, a significance level of 0.01% and allowed for 50% attrition, which was defined based on a previous online study (Boyce & Kuijer, 2015). This would also be sufficient for finding a significant weight change in participants, as a sample of at least 114 students would be needed to detect a difference of 1.8 kg (sd 2.6) in mean weight between baseline and follow-up, with 95% power at 0.1% significance, and allowing for 50% attrition. The calculation of the sample size was performed using G*Power 3.1.5 software.

5.3.3 Procedure

Students were invited to take part in this online prospective study at the beginning of the academic year (September/October 2015) through an email circular from their Departments or Faculties. The recruitment email had information about the study and the link to the online questionnaire. Interested students who consented to participate were invited to click on the link, which directed them to the online survey (see Appendix 5.2) set up on Survey Monkey (hhttp://www.surveymonkey.com.uk/) At 6-month follow-up (March/April 2016), all participants who provided a valid email were invited to complete the online survey for the second time. Each survey took around 5 minutes to complete. As an incentive, participants had the chance to enter a draw to win a £20 high street voucher. The incentive was used as an attempt to reduce attrition between the two online data collections. Three reminders to complete the follow-up survey were sent to participants. Ethical approval was granted by the University College London Research Ethics Committee (Appendix 5.4).

5.3.4 Measures

5.3.4.1 Predictor variable

Eating self-regulatory skills at baseline was treated as a predictor variable. It was assessed using the 5-item Self-Regulation of Eating Behaviour Questionnaire (SREBQ) (Kliemann, Beeken, Wardle, & Johnson, 2016), developed and validated as part of this thesis (Study 1, Chapter 4). Response options ranged from 1 (never) to 5 (always). Total mean score was calculated.

5.3.4.2 Outcome variables

Weight and dietary variables were treated as outcome variables. Weight and height were self-reported, as first year students tend to provide reliable anthropometric data. A review by Vella-Zarb and Elgar (2009) showed that the mean weight gain among first year students was very similar between studies which took students' self-reported and measured weight (mean change: 1.73 kg vs 1.75 kg respectively). Changes from baseline to 6-month follow-up were calculated for absolute weight in kg. Changes in weight were then categorised into two groups: ≥5% initial body weight (substantial weight gain) or <5% initial body weight. Additionally, Body Mass Index (BMI) was calculated by dividing weight in kilograms by the square of height in meters. Baseline BMI was categorised into underweight (BMI<18.5kg/m2); normal weight (BMI 18.5 to 24.9 kg/m2) or overweight or obese (BMI 25kg/m2 or over).

The dietary questions were the same as those used in the previous chapter (Study 1) to assess daily servings of fruit and vegetables (F&V) and occasions of sweet and salty snacks (SSS) and sugary drinks intake (SD). The response options ranged from 1 (less than once a week) to 7 (3 or more a day). Answers were recoded to represent daily intake, for example, '2-3 times a week' was coded as 0.36. High and low intake of F&V, SSS and SD were defined using percentile ranks of the scores at baseline. For F&V, the 75th percentile was the cut-off point for high intake, while scores that fell below this percentile represented a low intake. Regarding SSS and SD, the 25th percentile was the cut-off point for low intake, and scores above this percentile were classified as high intake. Participants who presented a high F&V and a low SSS and SD at 6 months, where those who managed to maintain or achieve healthier dietary behaviours over 6 months. Absolute changes from baseline to follow-up were not calculated as this could lead to misconceptions since people who scored at the higher or lower end of the spectrum would not have so much room to change.

5.3.4.3 Socio-demographic and other variables

Socio-demographic questions were the same as those used in the previous chapter (Study 1). They included questions on age, gender and ethnicity (White; Black; Asian; Mixed or Other). The question on living arrangements was adapted to reflect the most common accommodation options for first year undergraduate students. They had to choose the best option that reflected their current residence: living in college/university halls, renting from the local authority or privately, living with parents or owning their home.

Other variables were also collected, such as the name of the participants' university and which year of university they were in, in order to confirm they met the inclusion criteria. Additionally, as first year undergraduate students tend to increase their consumption of alcohol (Nikolaou et al., 2015), a question on the frequency of alcoholic drinks (AD) consumption was created and added to the online survey: 'How frequently do you typically drink alcoholic drinks?'. As with the dietary behaviour questions, response options ranged from 1 (less than once a week) to 7 (3 or more a day) and were recoded to represent daily intake. The 25th percentile at baseline was the cut-off point for low intake, and scores above this percentile were classified as high intake.

5.3.5 Statistical analyses

Prior to analysis, data was examined for outliers and normality. Normality was visually checked by plotting histograms and P-Plots and also by looking at the distribution of the variables, including measures of mean, median, skewness and kurtosis. Following the recommendation for medium samples (~300 participants), skewness >2 and kurtosis >7 were used as reference values for substantial departure from normality (Kim, 2013). Outliers were defined as absolute z-scores greater than 3.29 (Field, 2013). Analyses were performed with and without outliers, and as the results did not change when outliers were excluded, results for the full sample results are reported.

Descriptive analyses were used to characterise the sample, including information on age, gender, ethnicity, living arrangements, weight status, university and baseline data for weight, dietary intake, alcohol intake and self-regulation. Baseline differences between completer and drop-out participants were checked. Chi-square tests were used to assess differences in categorical variables, and T-test or Mann-Whitney tests were used to assess mean differences.

Pearson's or Spearman's correlations were carried out to assess the associations between eating self-regulatory skills, weight, dietary intake and socio-demographic characteristics at baseline. For the purpose of this analysis, ethnic origin was dichotomised into white ethnicity or other ethnicity; and living arrangements into living in college/ university halls or not; living with parents or not; and renting or owing a home or not.

Changes in weight between baseline and 6-month follow-up was explored using paired t-tests. Cohen's effect size was calculated. Mean change, standard deviation and range of changes are presented. Percentage of people who gained 5% of their initial body weight and who maintained or achieved a high intake of F&V and low intake of SSS and SD at 6-month follow-up are also reported. Chi-square tests were used to assess differences in dietary behaviours (percentage of high and low intake) over 6 months.

Regression models were used to explore whether eating self-regulatory skills at baseline predicted weight changes, 5% weight gain and healthier dietary behaviours over the first 6 months at university. For all analyses an unstandardized model including only eating self-regulatory skills was initially run. Thereafter the effect of covariates was explored, which were chosen based on the evidence from the literature (discussed in the introduction) and the correlation results between outcomes, exposure and potential covariates (see Appendix 5.4). Some covariates were included even though no significant correlations between them and the outcomes and exposure were found, as for example age, gender and ethnicity. This was done because adjusting for some variables that do not affect the expected total causal effect between exposure and outcome may improve precision, although they are also considered unnecessary (Schisterman, Cole, & Platt, 2009). All the regression analyses also tested the inclusion of alcoholic drinks intake at follow-up on the prediction of weight changes. However, since its inclusion did not improve the model fit, it was removed from the analyses.

Hierarchical multiple linear regression analyses explored the effect of eating self-regulatory skills on weight changes. The first step included only eating self-regulatory skills, while age, gender, ethnic origin, baseline BMI and height changes were entered in step 2 and interactions between eating self-regulatory skills and covariates were entered in step 3. Only significant interactions were included. Independent variables were centred to reduce the risk of multicollinearity. Assumptions for linearity, homoscedasticity and normality of residuals were checked. Multicollinearity was assessed using Tolerance (>0.1) and VIF (<10) values and influential cases were assessed using Cook's distances (<1).

Binary logistic regression was performed to explore the effect of eating self-regulatory skills on risk of gaining 5% of initial body weight and on maintaining or achieving healthy dietary behaviours at 6-month follow-up. Separate models were run for each outcome. Following the same order as in the linear regression, binary models included eating self-regulatory skills in step 1, covariate variables in step 2 and interaction terms between self-regulatory skills and covariates in step 3. Independent variables were also centred to lessen risk of multicollinearity. Linearity between the continuous independent variables and the logit of the dependent variables were checked. Likelihood ratio tests were used to ascertain whether the inclusion of each predictor significantly improved the model. Cox & Snell R square and Nagelkerke R square values were checked to understand the variation in the dependent variable explained by the model.

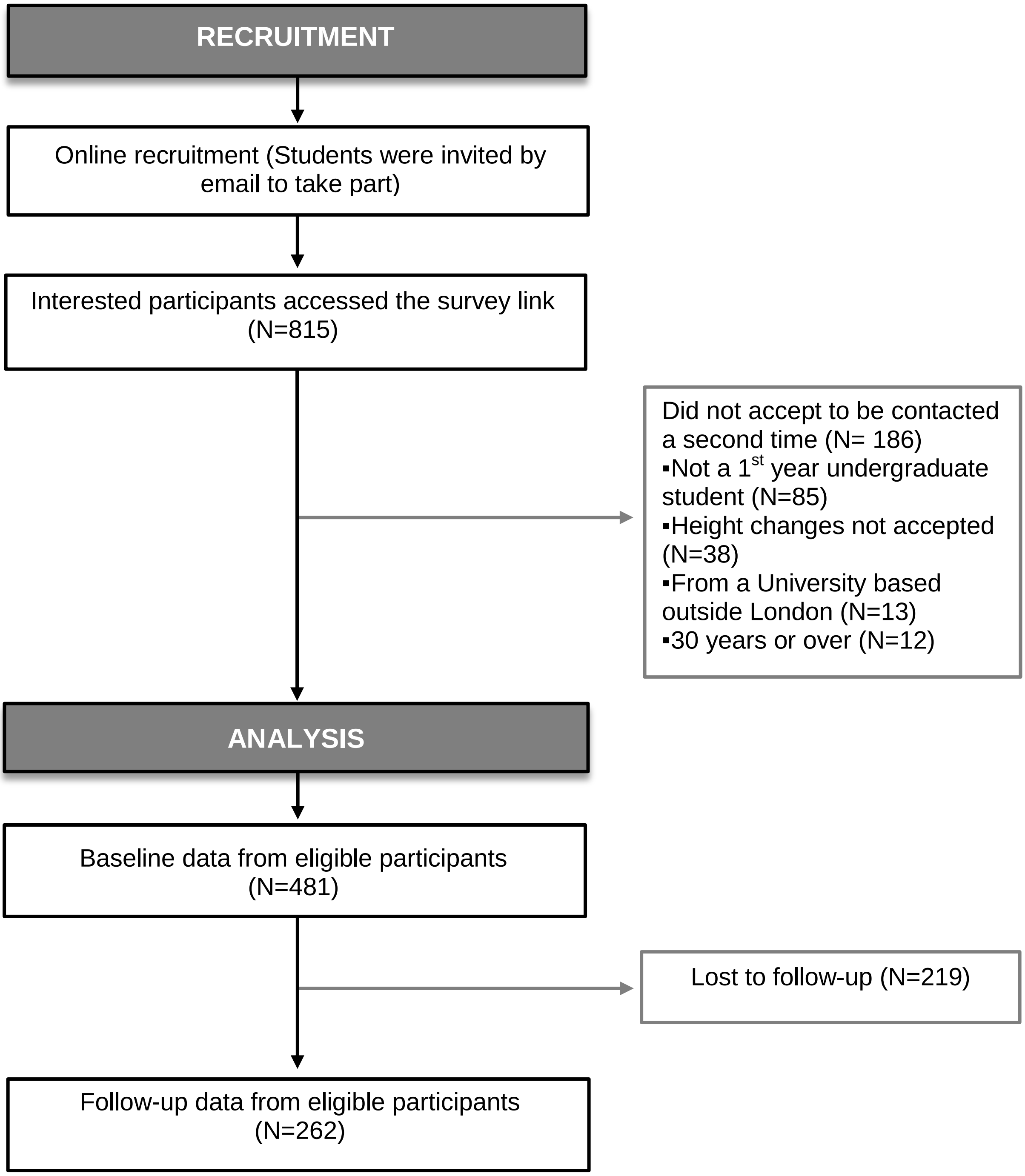
Significant interactions are illustrated using bar charts. To facilitate this illustration, baseline SREB was split into high or low, based on the cut-off scores suggested for this scale (Kliemann et al., 2016), where high self-regulation was set as any score >3.6 and lower (or medium) as any score ≤ 3.6. Also, to better understand the interactions, baseline BMI was categorised into high (BMI>21.3) and low (BMI≤21.3), based on the BMI mean, as the samples of underweight and overweight and obese participants were too small to use standard weight cut-offs.

No sensitivity analyses were performed as the Little's MCAR test indicated that data was missing at random ($\chi^2(86)=107.19$, $p=0.061$). All analyses were performed using IBM SPSS statistics version 22 (SPSS Inc., Chicago, IL, USA). Due to the number of analyses, a more stringent *p*-value of ≤0.01 was considered statistically significant for this study.

5.4 Results

A total of 815 students were interested in taking part in the study and provided baseline data. Of these, 334 had to be excluded for the following reasons: did not accept to be contacted a second time (N=186); were not a first year undergraduate student (N=85); reported a height change outside the acceptable range (N=38); were from a university based outside London (N=13); or were 30 years or over (N=12).The final sample consisted of 481 students. However, only 262 completed the 6-month follow-up survey, representing a 54.3% follow-up rate (see Figure 5.1).

Figure 5.1 Study Flowchart



5.4.1 Sample characteristics

The sample's characteristics at baseline are presented in Table 5.1. The majority of the participants were female (76.5%), white (59.7%), living in halls (70.7%) and had a healthy weight (73.4%). Most were students at universities based in Central London (83.6%), followed by South London (9.4%). The mean age was 19 years old and the mean weight was 60 kg. Students reported consuming on average less than 2 servings of fruit and vegetables per day and having sweet and salty snacks 4-6 times per week and sugary drinks and alcohol 2-3 times a week. A total of 262 participants provided data at 6-month follow-up and they did not differ significantly from non-completers at baseline for the majority of the variables, with the exception of gender, ethnicity and sugary drink intake. The completer group had a significantly higher proportion of female (80.9% vs 71.2%, p=0.01) and white (64.9% vs 53.4%, p=0.012) participants and tended to drink sugary drink less frequently at baseline (0.28 vs 0.37, p=0.020).

Table 5.1 Sample characteristics at baseline

Variable	Cut-off point	Baseline (N=481)		Completers (N=262)		Non-completers (N=219)		Statistic[¥]
		N	% or Mean(sd)	N	% or Mean(sd)	N	% or Mean(sd)	
Gender								
Female	-	368	76.5	212	80.9	156	71.2	$\chi^2(1)=6.22$, $p=$**.01**
Age in years								
Mean (sd)	-	481	19(1.65)	300	19(1.7)	219	18.9(1.6)	Mann Whitney $p=.632$
Ethnic group								
White	-	287	59.7	170	64.9	117	53.4	$\chi^2(2)=6.511$, $p=$**.012**
Other[a]	-	194	40.3	92	35.1	102	46.6	
Living arrangement								
University/College halls	-	340	70.7	192	73.3	148	67.6	$\chi^2(2)=2.480$, $p=.302$
Living with parents	-	61	12.7	28	10.7	33	15.1	
Renting/owing home[b]	-	80	16.6	42	16.0	38	17.4	
Universities by region								
North London	-	13	2.7	9	3.4	4	1.8	$\chi^2(4)=7.135$, $p=.126$
Central London	-	402	83.6	226	86.3	176	80.4	
South London	-	45	9.4	19	7.3	26	11.9	
East London	-	11	2.1	5	1.9	6	2.7	
West London	-	10	2.3	3	1.1	7	3.2	
Weight at baseline								
Mean (sd)	-	478	60.4(10.6)	298	60.2(10.3)	218	60.7(11.1)	$t(449.3)=-.56$, $p=.57$
Weight status[c]								
Underweight[c]	*<18,5*	73	15.2	34	13.0	39	17.8	$X^2(2)=2.93$, $p=.233$
Normal weight[d]	*18.5-24.9*	353	73.4	200	76.3	153	69.9	
Overweight/ obese[e]	*≥25*	52	10.8	26	10.0	26	11.8	
BMI at baseline								
Mean (sd)	-	478	21.3(3.1)	298	21.3(3.2)	218	21.3(3.0)	$t(476)=.023$ $p=.982$
Low	*≤21.3*	266	55.6	153	58.8	113	51.8	$X^2(1)=2.362$, $p=.139$
High	*>21.3*	212	44.4	107	41.2	105	48.2	
Fruit and Vegetable[d]								
Mean (sd)	-	481	1.6(1.0)	300	1.61(1.0)	219	1.50 (.99)	$t(479)=-1.19$ $p=.234$
Low	*≤2.25*	359	74.6	190	72.5	169	77.2	$X^2(1)=1.362$, $p=.249$
High	>2.25	122	25.4	72	27.5	50	22.8	
Sweet/ salty snacks[e]								
Mean (sd)	-	481	.70(.6)	300	.70(.69)	219	.70(.60)	$t(479)=-.134$ $p=.893$
Low	*≤0.36*	240	49.9	136	51.9	104	47.5	$X^2(1)=.932$, $p=.360$
High	>0.36	241	50.1	126	48.1	115	52.5	
Sugary drinks[e]								
Mean (sd)	-	481	.32(.5)	300	.28 (.53)	219	.37 (.59)	Mann Whitney $p=.020$
Low	*≤0.1*	212	44.1	127	48.5	85	38.8	$X^2(1)=4.516$, p=.035
High	>0.1	269	55.9	135	51.5	134	61.2	
Alcoholic drinks[e]								
Mean (sd)	-	481	.27(.4)	300	.25 (.38)	219	.29 (.45)	$t(479)=1.03$ $p=.302$
Low	*≤0.1*	193	40.1	105	40.1	88	40.2	$X^2(1)=.001$, $p=.981$
High	>0.1	288	59.9	157	59.9	131	59.8	
Self-regulation[f]								
Mean (sd)	-	466	3.44(.68)	254	3.44(.70)	212	3.45(.66)	$t(464)=.068$ $p=.956$
Low	≤3.6	285	61.2	155	61.0	130	61.3	$X^2(1)=.004$, $p=.948$
High	>3.6	181	38.8	99	39.0	82	38.7	

Note= [a]Black, Asian, Mixed or other ethnicity. [b]Renting privately or renting from local authority/housing associations or owing their own home. [c]Weight status according to BMI (kg/m^2). [d]Servings per day at baseline. [e]Occasions of consumption per day at baseline. [f]Score for eating self-regulatory skills ranged from 1 to 5. [¥]Baseline differences between completers and non-completers. sd=standard deviation.

5.4.2 Baseline associations of eating self-regulatory skills with sample characteristics

At baseline, higher eating self-regulatory skills was associated with consuming more servings of F&V (r=0.30, $p<0.01$), fewer SSS occasions (r=-0.34, $p<0.01$) and lower SD intake (r=-0.22, $p<0.01$). These correlations represented a medium effect size. There was no significant correlation between baseline eating self-regulatory skills and baseline weight, gender, age, ethnicity or living arrangements (see Table 5.2).

Table 5.2 Correlations between weight, BMI, dietary intake, socio-demographic characteristics and eating self-regulatory skills at baseline

Baseline data	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1 SREB[a]												
2 Weight	-.11											
3 BMI	**-.14***	**.80***										
4 Fruit & Vegetables[b]	**.30***	**-.12***	-.10									
5 Sweet/Salty Snacks[c]	**-.34***	-.07	-.04	.01								
6 Sugary Drinks[d]	**-.22***	.04	.06	**-.15***	**.27***							
7 Age	.03	**.13***	**.20***	-.09	-.04	-.02						
8 Gender[e]	-.06	**-.50***	**-.13***	**.17***	.06	**-.13***	-.02					
9 Ethnic origin[f]	-.06	-.09	-.01	**-.16***	-.02	.09	-.01	-.05				
10 College halls[g]	.04	-.01	-.04	.06	-.05	-.02	**-.19***	-.03	-.08			
11 Living with parents[h]	-.02	-.09	-.02	.01	.04	-.02	-.02	.02	**.16***	**-.60***		
12 Renting/own home[i]	-.03	.07	.06	-.09	.02	.04	**.25***	.02	**-**.04	**-.69***	**-.17***	

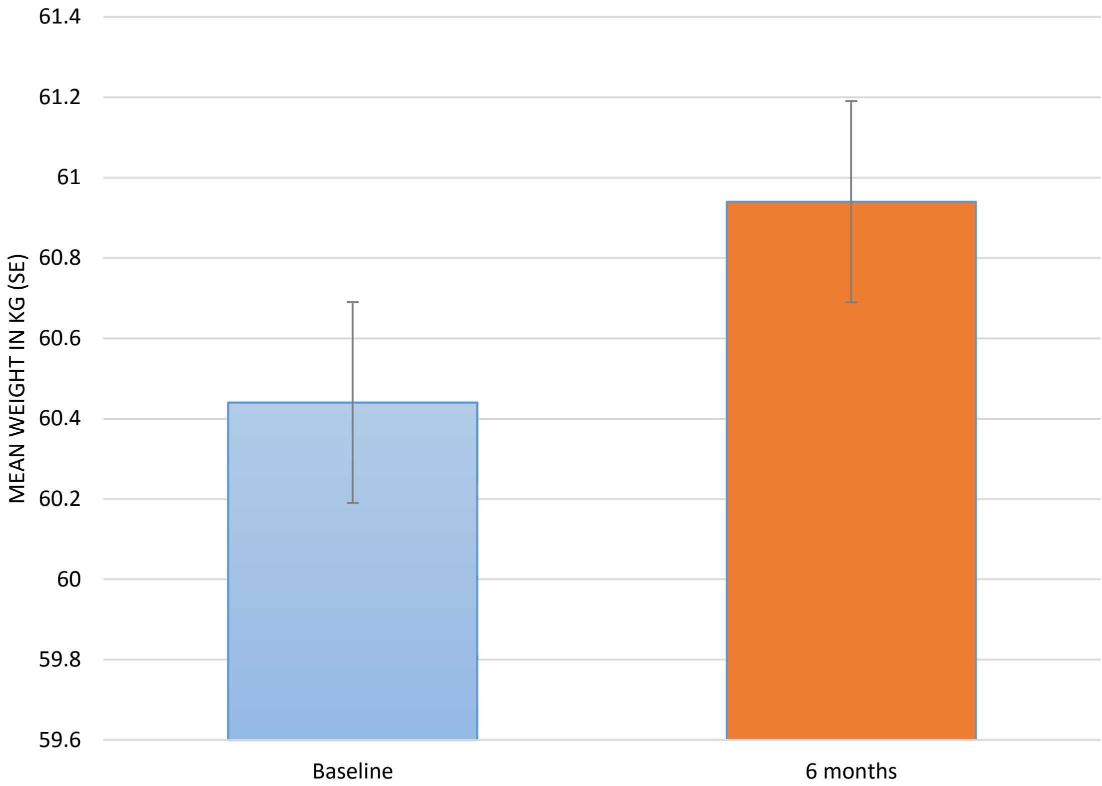
Note= [a]Eating self-regulatory skills, score range from 1 to 5**.** [b]Servings of fruit and vegetables per day. [c]Occasions of sweet and salty snack consumption per day. [d]Occasions of sugary drinks consumption per day. [e]Gender, Male=0 and Female=1. [f]Ethnicity, White=0 and Other=1. [g]College/University halls, No=0 and Yes=1. [h]Living with parents, No=0 and Yes=1. [i]Renting or owing their home, No=0 and Yes=1. 2-tailed *p*-value. *p<0.01

5.4.3 Follow-up differences in weight and dietary behaviours

5.4.3.1 Weight

Mean weight in kg at baseline and 6-month follow-up are presented in Figure 5.2. Over 6 months a mean weight change of 0.661 kg (sd=3.83) was observed, and this was statistically significant (t(254)=2.752, *p*=0.006), representing a small-sized effect (d=0.17). The range of weight change varied widely (-11.3 kg to 26.2 kg). No changes were reported in a small number of participants (19.6%, N=50), while about a third lost weight (30.6%, N=78) and about half gained weight (49.8%, N=127). Among students who showed an increase in their weight over 6 months (N=127), the mean weight gain was 3.30 kg (sd 3.16). Additionally, around a quarter of participants (23.5%, N=60) gained 5% or more of their initial body weight.

Figure 5.2 Mean weight in kg at baseline and 6-month follow-up



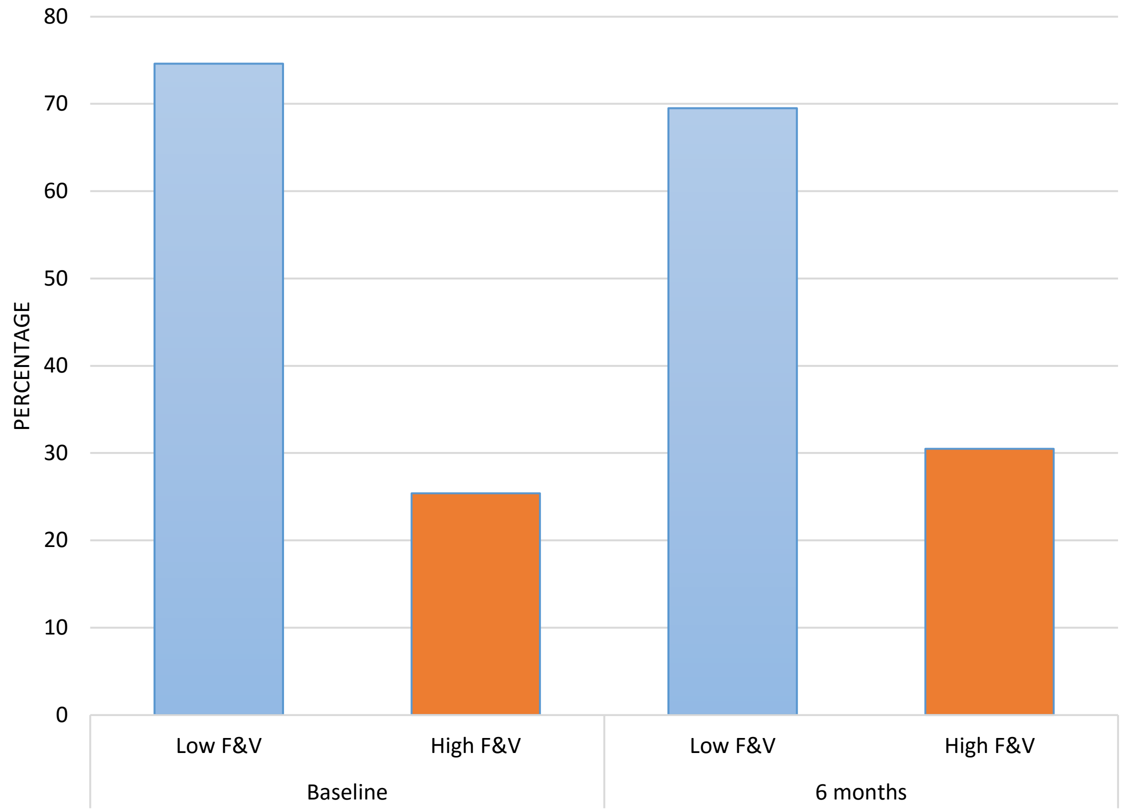
Note= t(254)=2.752, *p*=0.006, N=255.

5.4.3.2 Dietary behaviours

The results showed a slight increase (25.4 to 30.5%, *p*=0.14) in the percentage of people having a high F&V intake from baseline to 6-month follow-up, although this was not significant (see Figure 5.3). The percentage of people having a high frequency of SSS intake increased significantly (50.1 to 59.9%, *p*=0.01) over 6 months (see Figure 5.4). On the other hand, there was a significant decrease (55.9 to 46%, *p*=0.01) in the percentage of people having a high frequency of SD intake SD over 6 months (see Figure 5.5). This means that about 30% of participants managed to achieve or maintain a higher intake of F&V, while about 40% and 50%

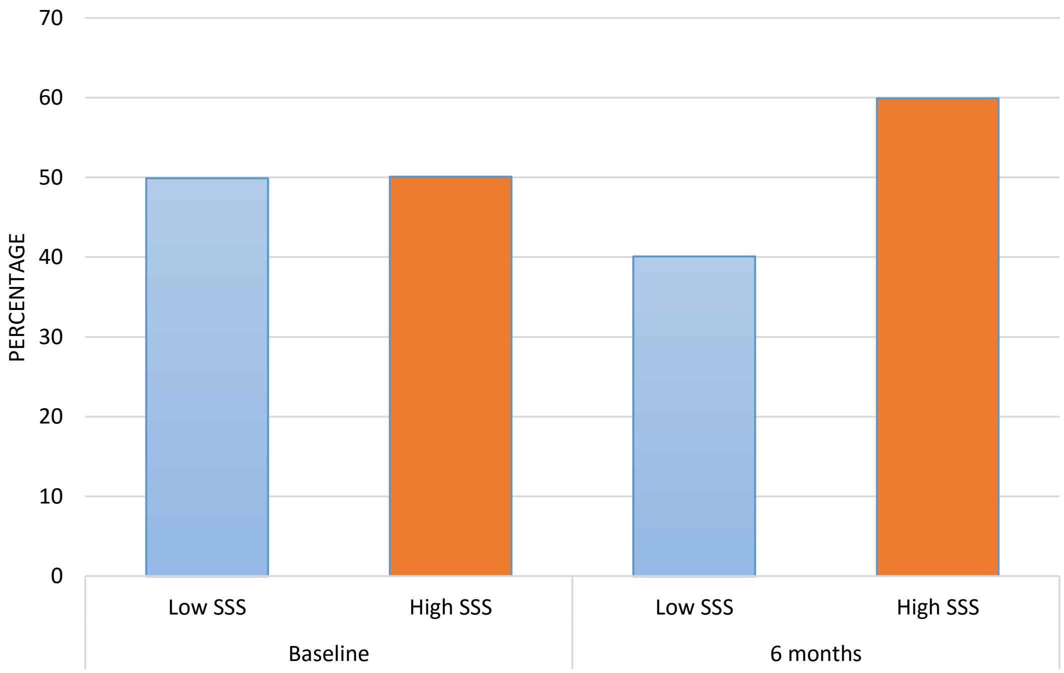
of participants managed to achieve or maintain a low intake of SSS or SD, respectively, over the first 6 months at university.

Figure 5.3 Percentages of low and high fruit and vegetables intake (number of daily servings) at baseline and 6-month follow-up



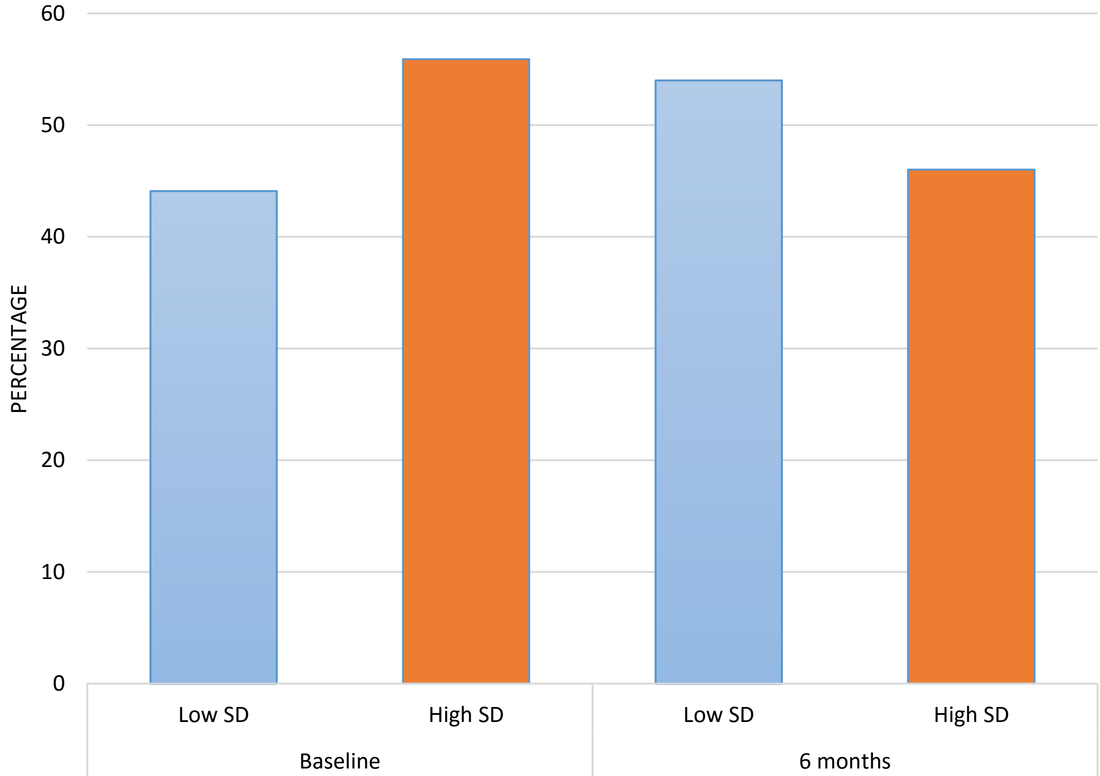
Note= Low F&V indicates an intake ≤ 2.25 daily servings and high F&V indicates an intake >2.25 daily servings. $X^2(1)=2.291$, $p=0.130$.

Figure 5.4 Percentages of low and high sweet and salty snacks intake (daily occasions) at baseline and 6-month follow-up



Note= Low SSS indicates an intake <0.36 daily occasions and high SSS an intake ≥ 0.36 daily occasions. $X^2(1)=6.576$, $p=.01$.

Figure 5.5 Percentages of low and high sugary drinks intake (daily occasions) at baseline and 6-month follow-up



Note= Low SD indicates an intake < 0.1 daily occasions and high SSS indicates an intake ≥ 0.1 daily occasions. $X^2(1)=6.714$, $p=.01$.

At 6-month follow-up, participants who showed a high F&V intake comprised 62.5% (N=50) who maintained a high intake and 37.5% (N=30) who increased their intake, while participants who showed low F&V comprised 87.9% (N=160) who maintained a low intake and 12.1% (N=22) who decreased their F&V intake. Regarding the participants that reported a low intake of SSS at follow-up, 64% (N=78) maintained a low intake and 36% (N=27) decreased their intake, while among participants that reported high SSS intake, 63.7% (N=100) maintained a high intake and 36.3% (N=57) increased their intake. With respect to SD intake at 6 months, those who reported low intake at 6-month follow-up comprised 72.4% (N=102) who maintained it low and 27.6% (N=39) who decreased their SD intake, while participants who reported high SD intake comprised 79.2% (N=95) who maintained it high and 20.8% (N=25) who increased their SD intake.

5.4.4 Eating self-regulatory skills as a predictor of differences in weight and dietary behaviours

5.4.4.1 Eating self-regulatory skills and weight changes at 6 months follow-up

A hierarchical linear regression was carried out to assess whether eating self-regulatory skills predicted weight changes over 6 months (see Table 5.3). The covariates were included based on the evidence from the literature and correlation results between outcomes, exposure and potential covariates (Table 5.2 & Appendix 5.4). The adjusted model (Model 2) included age, gender, ethnic origin, baseline BMI, and height changes as covariates and accounted for 6.8% of the variance in weight changes (p=0.009). However, only baseline BMI was a significant predictor (β=-0.21, p=0.002). Hence, at 6 months follow-up, weight increased more among students with a lower BMI at baseline. Model 3 explored whether there was an interaction between SREB and other covariates, and the inclusion of these interaction terms significantly improved the model fit by 7% (ΔF=9.986, p<0.001). Results from Model 3 showed that eating self-regulatory skills was a significant predictor of weight changes (β=-0.15, p=0.01), alongside baseline BMI (β=-0.30, p<0.001). There was also an interaction between baseline BMI and eating self-regulation (β=-0.25, p<0.001) and between ethnicity and eating self-regulatory skills (β=0.16, p=0.011). Therefore, the results indicated that self-regulatory skills moderated the relationship between baseline BMI and weight changes and between ethnicity and weight changes.

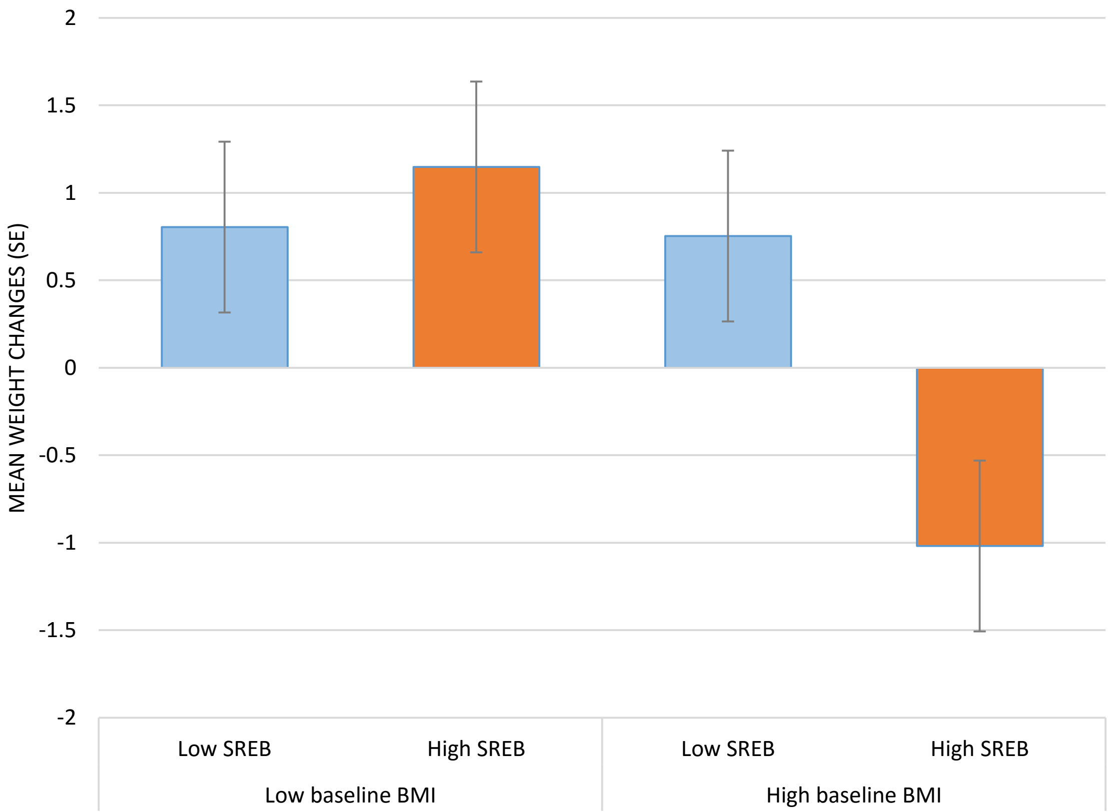
Table 5.3 Predictors of changes in weight at 6-month follow-up

Weight Changes	Model 1 Unadjusted			Model 2 Adjusted			Model 3 Adjusted		
	B (SE)	β	*p*	B(SE)	β	*p*	B(SE)	β	*P*
Constant	.58 (.22)		.009	.59 (.22)		.008	.49 (.22)		.025
SREB[a]	-.41 (.32)	-.07	.194	-.64 (.32)	-.13	.045	-.73 (.30)	-.15	**.018**
Age				.09 (.13)	.04	.491	.04 (.13)	.02	.748
Gender[b]				-.46 (.56)	-.06	.413	-.54 (.55)	-.06	.327
Ethnicity[c]				-.70 (.46)	-.09	.130	-.73 (.45)	-.10	.103
Baseline BMI				-.23 (.07)	-.21	**.002**	-.32 (.07)	-.30	**<.001**
Height changes				.47 (.23)	.13	.037	.43 (.22)	.12	.049
Ethinicity*SREB							1.58 (.62)	.16	**.011**
BMI*SREB							.38 (.09)	.-.25	**<.001**
Model fit	R^2=.007 & R^2 adj=.003 F=1.694, *p*=.194			R^2=.068 & R^2 adj=.044 F=2.909, *p*=**.009** ΔR^2=.061, ΔF=3.137, *p*=**.009**			R^2=.14 & R^2 adj=.11 F=4.842, *p*<.**001** ΔR^2=.07, ΔF=9.986, *p*<**.001**		

Note= [a]Eating self-regulatory skills at baseline. [b]Gender, Male=0 and Female=1. [c]Ethnicity, White=0 and Other=1.

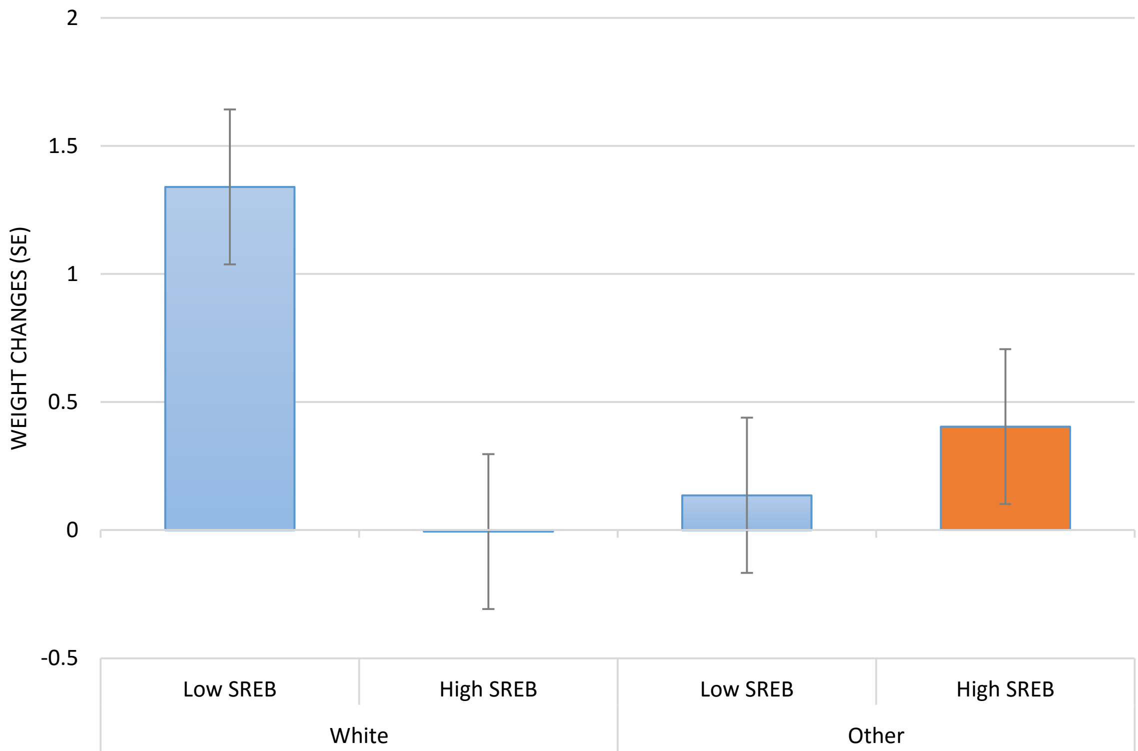
Figure 5.6 illustrates that higher eating self-regulatory skills (>3.6) predicted decreases in weight among students with a higher baseline BMI (BMI ranged from 21.30 to 47.13 kg/m^2), while those with a lower baseline BMI (BMI ranged from 15.19 to 21.26 kg/m^2) showed increases in weight regardless their baseline level of eating self-regulatory skills. Regarding the results for ethnicity, Figure 5.7 shows that lower eating self-regulatory skills predicted increases in weight among white students, while no effect was found for other ethnicities.

Figure 5.6 Interaction between baseline BMI and baseline eating self-regulatory skills as a predictor of changes in weight at 6-month follow-up



Note= SREB= baseline eating self-regulatory skills, where low SREB indicates a score≤3.6 and high SREB indicates a score>3.6. Weight changes from baseline to 6-month follow-up. BMI= Body Mass Index, where Low baseline BMI indicates a BMI≤21.3 kg/m^2 and High baseline BMI indicates a BMI>21.3kg/m^2. Mean weight changes adjusted for age, gender, ethnicity and height changes.

Figure 5.7 Interaction between ethnicity and baseline eating self-regulatory skills as a predictor of changes in weight at 6-month follow-up



Note= SREB= baseline eating self-regulatory skills, where low SREB indicates a score≤3.6 and high SREB indicates a score>3.6. Weight changes from baseline to 6-month follow-up. Mean weight changes adjusted for age, gender, baseline BMI and height changes.

5.4.4.2 Eating self-regulatory skills and 5% weight gain at 6 months follow-up

With respect to the risk of substantial weight gain, the mean for eating self-regulatory skills among students who gained 5% of initial body weight or over was 3.30 (sd=0.71) and among those who did not gain 5% of initial body weight the mean was 3.50 (sd=0.70). A logistic regression was performed to ascertain whether baseline eating self-regulatory skills was a predictor. As explained before, the covariates were included based on the evidence from the literature and correlation results between outcomes, exposure and potential covariates (Table 5.2 & Appendix 5.4). Model 1 unadjusted and Model 2 adjusted for age, gender, ethnicity, baseline BMI and height changes were not statistically significant (p>0.05). The model fit improved significantly with the inclusion of an interaction between eating self-regulatory skills and baseline BMI ($\Delta X^2(6)=7.23$, $p=0.007$). However, the inclusion of interactions between SREB and socio-demographics did not improve the model fit and therefore these were excluded from the final model. Table 5.4 shows that the full model (Model 3) explained from 7% to 11% of the variance in risk of a substantial weight gain, correctly classifying 77% of cases. According to this model, lower eating self-regulatory skills and BMI at baseline were associated with an increased likelihood of gaining at least 5% of initial body weight ($OR_{SREB}=0.52$, $p=0.006$ & $OR_{BMI}=0.80$, $p=0.003$).

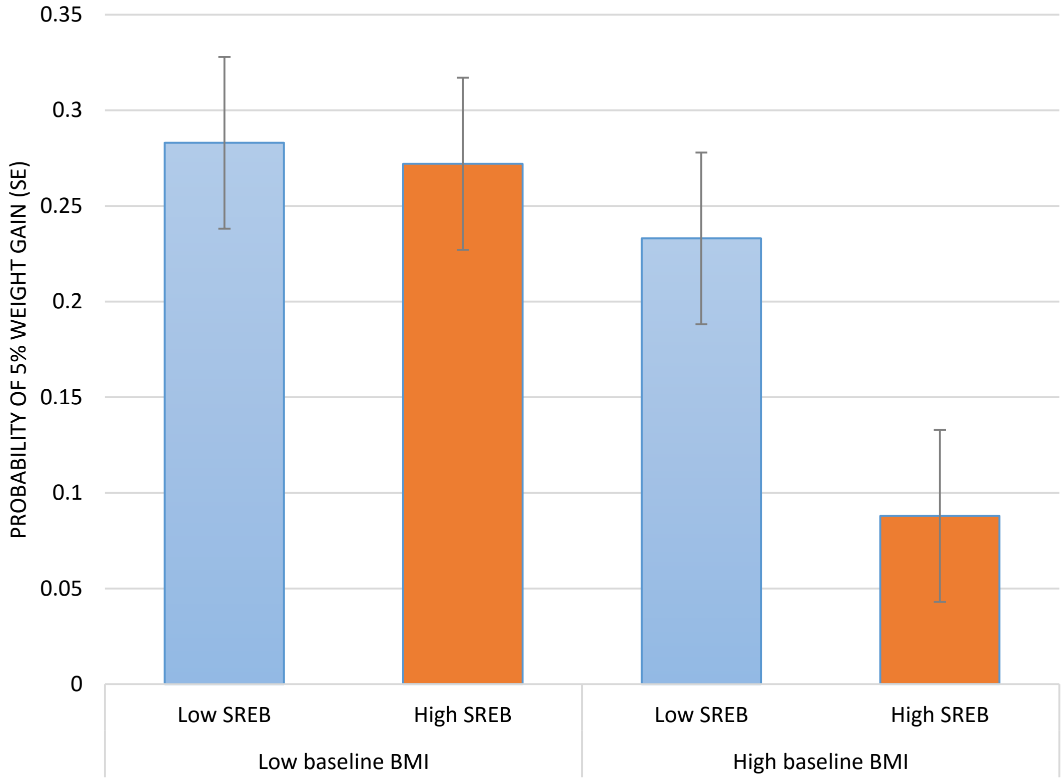
Table 5.4 Predictors of gaining 5% of initial body weight or over at 6-month follow-up

	Gain 5% weight gain								
	Model 1 Unadjusted			**Model 2 Adjusted**			**Model 3 Adjusted**		
	B(SE)	OR (95%CI)	*p*	B(SE)	OR (95%CI)	*p*	B(SE)	OR (95%CI)	*p*
Constant	-1.2 (.15)		**<.001**	-1.2 (.16)		**<.001**	-1.4 (.18)		**<.001**
SREB[a]	-.39 (.21)	.68(.44;1.03)	.071	-.50 (.22)	.60(.39;.94)	.025	-.66 (.24)	.52(.32;.83)	**.006**
Age				-.04 (.10)	.96(.78;1.17)	.684	-.04 (.10)	.96(.78;1.17)	.697
Gender[b]				.16 (.40)	.85(.38;1.88)	.696	-.17 (.41)	.84(.37;1.9)	.679
Ethnicity[c]				.28 (.33)	.75(.40;1.45)	.402	-.36 (.34)	.69(.36;1.35)	.288
Baseline BMI				-.13 (.06)	.87(.77;.99)	.032	-.21 (.07)	.80(.70;.93)	**.003**
Height changes				.14 (.15)	1.15(.85;1.5)	.365	.13(.16)	1.14(.84;1.5)	.392
BMI*SREB							-.20 (.07)	.82(.70;.95)	**.008**
Model fit	R^2=.013 to .020 $X^2(1)=3.290$, p=.070			R^2=.043 to .064 $X^2(5)=10.799$, p=.185 $\Delta X^2(4)=7.509$, p=.095			R^2=.070 to .11 $X^2(1)=18.036$, p=**.01** $\Delta X^2(6)=7.237$, p=**.007**		

Note= [a]Eating self-regulatory skills at baseline. [b]Gender, Male=0 and Female=1. [c]Ethnicity, White=0 and other=1. R^2= 'Cox & Snell R^2' to' Nagelkerke R^2'.

These results also suggest that self-regulatory skills moderated the relationship between baseline BMI and 5% weight gain (OR=0.82, $p=0.008$). As shown in Figure 5.8, students with a higher baseline BMI (BMI>21.3 kg/m^2) and higher baseline eating self-regulatory skills (score >3.6) had lower risk of gaining at least 5% of their initial body weight over the first 6 months at university than those with a higher BMI and lower baseline eating self-regulatory skills.

Figure 5.8 Interaction between baseline BMI and baseline eating self-regulatory skills as a predictor of gaining 5% of initial body weight or over at 6-month follow-up



Note= SREB= baseline eating self-regulatory skills, where low SREB indicates a score≤3.6 and high SREB indicates a score>3.6. BMI= Body Mass Index, where Low baseline BMI indicates a BMI≤21.3 kg/m^2 and High baseline BMI indicates a BMI>21.3kg/m^2. Predicted probability of gaining 5% of initial body weight adjusted for age, gender, ethnicity and height changes.

5.4.4.3 Eating self-regulatory skills and dietary behaviour at 6 months follow-up

Students who maintained or achieved a high F&V consumption showed a mean for eating self-regulatory skills at baseline of 3.61 (sd=0.64), whereas those who worsened to or maintained a low F&V intake had a mean of 3.36 (sd=0.72). Students who maintained or achieved a low intake of SSS scored on average 3.63 (0.63), while those who increased to or maintained a high intake scored 3.32 (sd=0.72) for eating self-regulatory skills. Similarly, students who maintained or achieved a low SD intake scored on average 3.52 (sd=0.69) on eating self-regulatory skills and those who increased to or maintained a high intake scored 3.35 (sd=0.71). A logistic regression was conducted to assess whether baseline eating self-regulatory skills was a predictor of maintaining or achieving a healthier diet (see Table 5.5) at 6-month follow-up when adjusting for socio-demographic variables. All logistic regression models included eating self-regulatory skills in step 1; age, gender, ethnicity and baseline BMI in step 2; and the interaction between baseline data for eating self-regulatory skills and covariates in step 3. However, as the interactions were not significant for any model, only the results for the two-step models are presented in Table 5.5.

According to the unadjusted model, eating self-regulatory skills at baseline significantly predicted higher F&V intake (p=0.008). The inclusion of socio-demographic variables to the model 2 improved the model fit significantly ($\Delta X^2(4)$=18.907, p=0.001), and this final model explained from 9% to 14% of the variance in F&V intake and classified 66% of the cases correctly. Greater baseline eating self-regulatory skills (OR=1.8, p=0.007) and being female (OR=4.3, p=0.002) were associated with an increased likelihood of maintaining or achieving a higher consumption of F&V at 6 months follow-up.

With respect to the logistic regression model for maintaining or achieving a low consumption of SSS, the unadjusted model showed that eating self-regulatory skills was a significant predictor (OR=1.9, p=0.001). Although the inclusion of socio-demographic variables did not significantly improve the model fit ($\Delta X^2(4)=1.035$, $p=0.904$), the likelihood ratio test increased. This model (Model 2) explained from 4.8% to 6.5% of the variance in SSS intake and correctly classified 62% of the cases. The results indicated that higher baseline levels for eating self-regulatory skills was related to a greater likelihood of maintaining or achieving a lower consumption of SSS over 6 months. None of the covariates were found to be related to the outcome.

Finally, the results for the unadjusted model for a low SD intake at 6-month follow-up indicated that greater eating self-regulation was related to an increased chance of maintaining or achieving a low SD intake (OR=1.45, $p=0.041$), however this did not reach the stringent cut-off for significance established for this study ($p \leq 0.01$). The inclusion of covariates (Model 2) also did not improve the model fit ($\Delta X^2(4)=6.935$, $p=0.139$). The model explained from 4.4% to 5.8% of the variance in SD intake and classified 59% of cases correctly.

Table 5.5 Predictors of maintaining or achieving a healthier dietary intake at 6-month follow-up

	Maintained or achieved healthier dietary behaviours					
	Model 1 Unadjusted			**Model 2 Adjusted**		
	B(SE)	OR (95%CI)	*p*	B(SE)	OR (95%CI)	*P*
High F&V intake[a]						
Constant	-.79 (.14)		**<.001**	-.987 (.16)		**<.001**
SREB[d]	.54 (.20)	1.71 (1.1; 2.5)	**.008**	.59 (.22)	1.8 (1.1; 2.7)	**.007**
Age				-.19 (.10)	.82 (.66; 1.0)	.060
Gender[e]				1.4 (.47)	4.3 (1.7; 10.9)	**.002**
Ethnicity[f]				-.57 (.31)	.56 (.30; 1.0)	.066
BMI baseline				.03 (.05)	1.0 (.93; 1.13)	.511
Model fit	R^2=.029 to .041 $X^2(1)$=7.402, *p*=**.007**			R^2=.09 to .14 $X^2(5)$=26.308, *p*<**.001** $\Delta X^2(4)$=18.907, *p*=**.001**		
Low SSS intake[b]						
Constant	-.43 (.13)		**.001**	-.43 (.13)		**.001**
SREB[d]	.64 (.19)	1.9 (1.2; 2.7)	**.001**	.64 (.20)	1.9 (1.3; 2.8)	**.001**
Age				-.05 (.08)	.95 (.80; 1.1)	.551
Gender[e]				-.24 (.34)	.78 (.40; 1.5)	.479
Ethnicity[f]				-.09 (.28)	.91 (.52; 1.6)	.737
BMI baseline				.01 (.04)	1.0 (.93; 1.1)	.789
Model fit	R^2=.044 to .059 $X^2(1)$=11.307, *p*=**.001**			R^2=.048 to .065 $X^2(5)$=12.343, *p*=.030 $\Delta X^2(4)$=1.035, *p*=.904		
Low SD intake[c]						
Constant	.19 (.13)		.140	1.44 (.13)		.275
SREB[d]	.37 (.18)	1.45 (1.0; 2.1)	.041	.36 (.18)	1.4 (.99; 2.01)	.053
Age				.03 (.08)	1.0 (.88; 1.2)	.688
Gender[e]				.80 (.34)	2.2 (1.1; 4.3)	.017
Ethnicity[f]				-.15 (.27)	.86 (.50; 1.5)	.581
BMI baseline				-.02 (.04)	.98 (.90; 1.0)	.685
Model fit	R^2=.017 to .023 $X^2(1)$=4.291, *p*=.038			R^2=.044 to .058 $X^2(5)$=11.226, *p*=.047 $\Delta X^2(4)$=6.935, *p*=.139		

Note= [a]Maintaining or achieving a consumption at least 2.25 servings of fruit and vegetable per day. [b]Maintaining or achieving a consumption of a maximum of 0.36 occasions of sweet and salty snacks per week. [c]Maintaining or achieving a consumption of a maximum of 0.1 occasions of sugary drinks per week. [d]Eating self-regulatory skills at baseline. [e]Gender – Male=0 and Female=1. [f]Ethnicity – White=0 and Other=1. R^2= 'Cox & Snell R^2' to' Nagelkerke R^2'.

5.5 Discussion

This study aimed to explore the impact of baseline eating self-regulatory skills on weight gain and healthy dietary behaviours in first year undergraduate students. As hypothesised, students who entered university with higher eating self-regulatory skills were more likely to maintain or achieve a healthier diet over the course of the first 6 months in university. Additionally, higher eating self-regulatory skills were related to decreases in weight and lower likelihood of gaining a substantial amount of weight (5% initial body weight) among students with higher baseline BMI (BMI>21.3kg/m^2).

Although weight gain (0.6 kg) was modest, around a quarter of the students gained a substantial amount of weight (≥5% initial body weight). This is in line with a recent study which weighed and measured 301 first year students in London over 7 months and found a weight gain of 0.54 kg, and that one in five gained at least 5% of their initial body weight (Meisel et al., 2015). Similar to Meisel et al. (2015) findings, around 90% of participants in the present study were classified as underweight or normal weight, and people with a lower BMI gained the most weight. However, this still conflicts with results from other studies, and there does not appear to be consistency around whether weight gain is related to a lower or higher baseline BMI in first year students (Finlayson et al., 2012; Mihalopoulos, Auinger, & Klein, 2008; Vella-Zarb & Elgar, 2009). According to a recent study, a potential explanation for these inconsistencies is the fact that baseline BMI appears to interact with other factors in order to promote weight gain (Boyce & Kuijer, 2015). This is in line with findings from the present study, which showed that higher eating self-regulatory skills protected against both increases in weight and substantial weight gain only among students with a higher baseline BMI. On the other hand, students with a lower baseline BMI gained weight regardless of their level of eating self-regulatory skills. However, the lower BMI group represented people classified as underweight to a BMI of 21.3 kg/m^2, therefore a weight gain in this group could represent a positive outcome. On the other hand, the higher BMI group represented people classified at the higher end of the normal weight spectrum as well as overweight or obese. The prevention of weight gain in this group is relevant, since people with higher BMIs are more genetically predisposed to gain weight in an obesogenic environment (Kautiainen et al., 2002; Wardle & Boniface, 2008), as discussed in Chapter 1. Self-regulation is therefore a potential target for interventions seeking to prevent substantial weight gain. Additionally, higher eating self-regulatory skills were also related to weight loss in the higher BMI group, but further studies should explore this in samples that include more overweight and obese participants, which would permit the analysis of normal weight and overweight people separately.

Previous studies have shown that ethnicity does not predict weight changes (Gillen & Lefkowitz, 2011; Roane et al., 2015), and this was also the case in the present study. However, a significant moderating effect of eating self-regulatory skills on the relationship between ethnicity and weight changes was found. White students, who had lower eating self-regulatory skills experienced greater increases in their weight over 6 months compared to those who had higher eating self-regulatory skills, while a smaller effect was found for people classified as 'other ethnicities'. According to a research study, white female students tend to be more concerned about gaining weight during the first year of university than black students (Webb et al., 2013). It is possible, therefore, that white students tend to apply more self-regulatory skills in order to control their weight and their capability may reflect their level of success.

Regarding the results for dietary behaviours, the level of eating self-regulatory skills at baseline was related to higher baseline F&V intake and lower baseline SSS and SD intake, in agreement with the results presented in Chapter 4. At 6 months follow-up, a third managed to maintain or achieve a high F&V intake and almost half managed to maintain or achieve a low SSS intake and SD intake. As anticipated, higher F&V and low SSS intake at 6-month follow-up were significantly predicted by higher baseline eating self-regulatory skills. Although lower SD intake was also related to higher eating self-regulatory skills, it did not reach the significance established for this study. However this study only assessed the differences in the frequency of SD intake. A systematic review has suggested that sugary drinks tend to be consumed in large portion sizes, due to their lower satiety effect compared to solid foods of the same energy density (Malik, Schulze, & Hu, 2006). Therefore, future studies should explore the effect of eating self-regulatory skills on the amount of sugary drinks consumed. Although the group who did not manage to maintain or achieve healthy dietary behaviours represented a heterogeneous group, they would be expected to have lower eating self-regulatory skills at baseline as some of them had unhealthy dietary behaviours at baseline or had a healthier diet that worsened over the first few months at university. Female students were also more likely to maintain or achieve a higher F&V intake during the study. Due to the small number of male students who took part in this study, future research should better explore the relationship between gender and dietary behaviours in first year students.

5.6 Study limitations

This study had limitations. Initially, the online recruitment, which was expected to be easier than face-to-face recruitment, proved to be a challenge. Many schools and departments did not reply to the request to invite their first year students to take part in the study. Furthermore, some of them refused to take part because they did not want to burden their students with lots of emails unrelated to their course. There were also restrictions due to the lack of ethical approval from their University, despite the fact that UCL had granted ethical approval for the study. As a consequence, the majority of the students were based at UCL or other universities in central London.

For convenience, only students from universities based in London were included in the study. As a consequence, the sample may not be representative of UK first year students, because London tends to have a lower percentage of overweight and obese compared to other regions of the UK (HSCIC, 2017). In fact, overweight and obese individuals were under-represented in the sample, which may explain the modest weight gain found in this study. Based on the Health Survey of England

(Moody, 2016), around 40% of a sample of this age should be made up of overweight and obese, however only 10.6% of sample fell into the overweight/obese categories. Men were also under-represented, suggesting that the participants who decided to take part in the study may differ from the general student population regarding their interest in a healthy diet and weight control.

There were also limitations related specifically to the measures used to assess dietary intake. In order to promote high retention rates, the online surveys were kept short and only four questions on food frequency were included. However, they lacked portion size information, were related to groups of foods rather than specific foods, and responses options ranged from 1 to 7. They also did not allow the calculation of overall energy intake. This may have limited the accuracy of the data collected. As a retrospective measure, this food frequency questionnaire also had the limitation of relying on individuals' memory. However, its unannounced and self-administered features as well as the fact that it captures habitual behaviours are important strengths of this method (Walton, 2015). Additionally, previous studies using these questions have showed that they seem to provide valid data on habitual dietary intake (Kliemann et al., 2016; McGowan et al., 2013).

A further limitation was that no data on physical activity was collected due to minimising the survey length and the fact the self-regulation questionnaire was related only to eating behaviours. This may have limited the ability of the study to better understand potential predictors of weight gain. Future studies should also explore the relationship between physical activity and weight gain and use a measure of self-regulation of activity behaviours.

Similarly, the understanding of the relationship between alcohol intake and weight gain was limited due to the measures used in this study. Alcohol intake was assessed using a frequency question that lacked on portion size information. However, evidence suggest that is the heavy episodes of drinking alcohol that increase during the transition from school to university, and the overall drinking tends to vary throughout the year, being relatively high at the start of the semester and low during exams (Borsari, Murphy, & Barnett, 2007; Del Boca, Darkes, Greenbaum, & Goldman, 2004). Additionally, the measure of self-regulation did not cover alcohol intake regulation. Therefore, the relationship between weight gain and alcohol intake in first year undergraduate students should be further investigated using food frequency questions on alcohol intake accounting for portion sizes and using a proper measure of self-regulation of alcohol intake.

Finally, students who completed the follow-up survey may have been somewhat different to those who did not respond. However, the follow-up sample appeared representative of the initial sample, apart from gender and ethnic origin.

5.7 Conclusions

Despite the limitations, this study provides evidence that higher baseline eating self-regulatory skills may help students to maintain or achieve a healthy diet and protect them against substantial weight gain, especially among students with higher BMIs. Weight gain prevention initiatives that include eating self-regulatory skills training should be tested.

CHAPTER 6: THE ROLE OF EATING SELF-REGULATORY SKILLS ON THE EFFECTIVENESS OF A BRIEF HABIT-BASED INTERVENTION ON WEIGHT LOSS BEHAVIOURS (STUDY 3)[1]

6.1 Introduction

Conclusions from the previous chapter (Study 2) suggest that weight management initiatives that include eating self-regulatory skills training should be tested, especially among people with higher BMIs. Considering that obesity is a growing public health concern that affects more than 600 million people worldwide (Afshin et al., 2017; Finucane et al., 2011) and increases risk for chronic diseases (Afshin et al., 2017; WHO, 2014), there is a clear need to understand the impact of eating self-regulatory skills training on weight loss behaviours in order to develop more effective interventions for this population. The scoping review in Chapter 2 discussed the potential to enhance eating self-regulatory skills through practice, and showed that brief weight loss and dietary interventions including planning, self-monitoring and feedback on performance techniques hold promise for improving self-regulatory skills. However, it highlighted a lack of studies exploring whether improving eating self-regulatory skills helps people to achieve and maintain healthy lifestyles. Therefore, the effect of weight loss interventions on eating self-regulatory skills, and the impact of self-regulatory skills changes on weight loss behaviours remains unclear.

Furthermore, none of the studies identified in Chapter 2 used a habit-based approach to promote lasting healthy lifestyles and weight loss. Habit-based interventions are of particular interest because they are considered to be scalable, and are thought to have the potential to improve self-regulatory skills. Interventions

[1] A version of this chapter has been published in IJBNPA (Appendix 6.1)

based on habit theory promote the repetition of target behaviours in a consistent context in order to make them become more automatic and habitual (Beeken et al., 2012; Verplanken & Wood, 2006). Habits are formed through learned associations between a cue or stimulus with a response, so that when a cue is encountered it automatically generates an impulse toward action (Gardner, 2014). Although the focus is on making behaviours habitual, the process of habit formation may also improve self-regulatory skills as individuals strive to translate the intended behaviour into action and override unwanted automated responses (Lally & Gardner, 2013; Nederkoorn et al., 2010). Interest is growing in habit-formation approaches (Lally & Gardner, 2013; Rothman, Sheeran, & Wood, 2009; Verplanken & Wood, 2006), but weight loss interventions applying this approach are still scarce (Gardner, 2015; Lally, Chipperfield, & Wardle, 2008) and their mechanisms of action are not completely understood.

Our research group developed a habit-based weight loss intervention, called 10 Top Tips (10TT), delivered as a leaflet to promote a set of everyday healthy eating and activity behaviours (Lally et al., 2008). In the 10TT, the advice for turning the target behaviours into habits involves the recommendation to make specific plans and repeat the behaviours in a consistent context, as well as monitoring performance daily using a log book. Thus, this intervention should require self-regulation practice during the habit acquisition phase, as previously identified by Gardner, Lally, et al. (2012). This intervention has recently been tested in patients with obesity (N=537) within the UK primary care setting (Beeken et al., 2017). The active treatment was defined as the first 3 months, which is the period usually required to form habits (Lally & Gardner, 2013; Lally, Van Jaarsveld, Potts, & Wardle, 2010). The results of this trial demonstrated that, over 3 months, patients allocated to 10TT lost 0.87 kg (95%CI -1.47; -0.027, adjusted mean) more than those allocated to usual care. Furthermore, patients who received 10TT reported a greater increase in automaticity of the target behaviours (adjusted sum difference = 8.45, 95%CI =2.59, 14.32) over 3 months, which suggests that 10TT was more effective at establishing new habits by the end of the intervention period. However, the impact of the 10TT intervention on the target behaviours (dietary, activity and weighing behaviours) has not been established. Furthermore, the effect of the 10TT intervention on eating self-regulatory skills is currently not known, nor whether these changes mediate the effect of the intervention on weight and behaviours.

6.2 Study aims and contribution to the literature

Therefore, the current study aimed to explore the role of eating self-regulatory skills on the effectiveness of 10TT at reducing weight and changing behaviour. Specifically, this study investigated the effect of 10TT on self-regulatory skills and target behaviours over 3 months and, whether changes in self-regulatory skills mediated the effect of the intervention on weight and behaviours. It also aimed to explore how engagement with the intervention impacted on changes in weight, self-regulatory skills and target behaviours. I hypothesised that i) 10TT would increase self-regulatory skills more than usual care; ii) 10TT would promote greater changes to the target behaviours than usual care; iii) changes in self-regulatory skills would mediate the effect of 10TT on weight loss and behaviours and; iv) participants with the greatest improvement in self-regulatory skills, target behaviours and weight loss would be more engaged.

Results from this study may improve the theoretical understanding of the mechanisms of action of habit-based interventions. More specifically, they may further the understanding of the role of eating self-regulatory skills on the effectiveness of habit-based interventions on weight loss and behaviours. Findings could therefore guide the development of more effective habit-based weight loss interventions to tackle the obesity epidemic.

6.3 Methods

6.3.1 Design

This study is a secondary analysis from a two-arm, individually-randomised (1:1 ratio), controlled trial in adults with obesity in primary care that compared the 10TT intervention with ‘Usual care’. The active treatment was defined as the first 3 months. The protocol and primary outcomes of the trial have been published elsewhere (Beeken et al., 2012; Beeken et al., 2017). These describe the methods fully, but an outline is provided below. The trial was funded by the Medical Research Council – National Prevention Research Initiative and designed according to the CONSORT 2010 guidelines. A completed checklist of information to be included when reporting a randomized controlled trial is shown in Appendix 6.1.

6.3.2 Participants and recruitment

Participants were patients from General Practices in England who were classified as obese (BMI≥ 30 kg/m^2) and who were 18 years or older. Patients were excluded if they were pregnant, terminally ill, or unable to provide informed consent due to mental incapacity or active psychotic illness. A total of 14 General Practices across England were selected through the General Practice Research Framework to try to represent socio-economically diverse populations and both urban and rural areas. A total of 9 General Practices were located in Southern England, 3 in the Midlands and 2 in the North. Six practices were located in urban areas and nine in rural areas. Two thirds of the practices were located within quintiles four and five, the two most deprived quintiles for England, and the rest were located in the second and third quintiles (Department for Communities and Local Government, 2010). All patients registered in these practices received an invitation to take part in the study between August 2010 and October 2011. However, when the number of patients with obesity registered in the practice exceeded 500, a random sample of 500 was selected and invited. The practices sent a letter to eligible patients with an information sheet (see

Appendix 6.2) and ‘expression of interest’ form which patients were asked to return to indicate their interest in participating. Interested, potential participants met with a health professional at their practice, who checked their eligibility, explained the study and took informed consent.

6.3.3 Randomisation

Randomisation took place once informed consent was taken and baseline measures completed. This was done by telephoning a central randomisation service (Health Service Research Unit at Aberdeen) to ensure allocation concealment. A computer-based list generated random permuted blocks of size 2 to 4. The randomisation was stratified by practice in order to have a socio-economic balance between the groups.

6.3.4 Sample size

The trial was powered to detect a significant weight difference (1.0 kg; sd=2.5) between the intervention and control group. Sample size tests were based on 90% power, a significance level of 5% and accounted for clustering due to different health professionals delivering the intervention. An attrition rate of 30% was assumed which resulted in 520 participants being required to be recruited, 260 in each arm. The trial was not powered to detect change on any of the secondary outcomes (including self-regulation and behaviour), therefore, the analyses presented in this study should be considered exploratory.

6.3.5 10TT intervention group

Participants randomised to the intervention group received the 10TT leaflet (see Appendix 6.3), a self-monitoring log book (Appendix 6.4) and a wallet sized shopping guide on how to read food labels (Appendix 6.5) at their baseline appointment by a trained health professional (nurses or health care assistants). The content of the 10TT materials were classified according to the CALO-RE Taxonomy of Behaviour

Change Techniques (BCTs) proposed by Michie et al. (2011). Table 6.1 lists the set of BCTs included in each of the 10TT materials.

Table 6.1 Summary of BCTs included in the 10TT intervention

Behaviour change techniques used in the 10TT intervention
10TT Leaflet
Provide information on consequences of behaviour in general
Goal setting (behaviour)
Goal setting (outcome)
Action planning
Set graded tasks
Prompt review of behavioural goals
Prompt review of outcome goals
Prompt self-monitoring of behaviour
Prompt self-monitoring of behavioural outcome
Provide information on where and when to perform the behaviour
Teach to use prompts/cues
Environmental restructuring
Prompt practice
Provide instruction on how to perform the behaviour
10TT Logbook
Action planning
Set graded tasks
Prompt review of behavioural goals
Prompt review of outcome goals
Prompt self-monitoring of behaviour
Prompt self-monitoring of behavioural outcome
Model/Demonstrate the behaviour
Teach to use prompts/cues
Prompt practice
Shopping guide
Provide instruction on how to perform the behaviour

Note= BCTs classified based on Michie, Ashford, et al. (2011)

The leaflet describes the target health behaviours, which were defined with input from researchers, clinicians and policy makers, and their scientific justification has been published elsewhere (Beeken et al., 2012). As the leaflet was designed to be accessible to everyone, it was written in easy language and each tip had a memorable name. Seven of the 10 tips were designed to promote negative energy balance behaviours (go reduced fat; caution with your portions; don't forget your 5 a day; walk off the weight; pack a healthy snack; up on your feet; think about your drinks). Two items were designed to promote greater nutrition awareness (learn the labels; focus on your food) and one promoted routines (keep your meal routine). It was estimated that a daily calorie deficit of 800 to 900 kcal could be achieved by someone moving from doing none of the tips to doing all of them.

The intervention was delivered by trained health professionals (nurses or health care assistants) within the practices. Training was delivered by the charity Weight Concern and involved an explanation of the study and how they should describe the information to participants. All health professionals were provided with a study manual, desktop flip chart outlining the intervention and standardised script. They were instructed to spend about 30 minutes talking through the leaflet with participants, and to provide them with the intervention materials. No further clinical contact was involved. Participants could request more log books as necessary and were asked to return the completed ones by post. The active treatment phase, during which participants were advised to monitor their behaviour using the log books, was defined as the first 3 months. According to Gardner, Lally, et al. (2012), working towards behavioural goals and repeating them over 2 to 3 months can make them habitual.

6.3.6 Usual care control group

Participants randomised to usual care received the practice's usual care, which typically consisted of providing lifestyle advice, referring patients to a community programme (12 weekly sessions) or referring patients to a dietitian (usually at least 2 appointments). Detailed information about the usual care received by participants has been previously published (Beeken et al., 2017).

6.3.7 Blinding

It was not possible to blind participants to their group condition. However, the assessment at 3 months was done by health professionals blinded to participant condition allocation.

6.3.8 Measures

For the present study, self-regulatory skills were treated as the primary outcome and behaviours as the secondary outcomes. A measure that combined the frequency of the target dietary, activity and weighing behaviours was used to provide an overall view of the impact of the intervention on the targeted weight loss behaviours. However, dietary intake was also looked at in more detail using validated measures, because the self-regulation questionnaire focuses specifically on eating behaviours. The measures used for the current study were taken at baseline and 3-month follow-up. Participants were asked to complete a survey (see Appendix 6.6) about their dietary and physical activity behaviours and self-regulatory skills, as well as other behavioural and psychological characteristics not included in the present study (Beeken et al., 2012). Anthropometric and demographic measures were also taken. Log books were used as a measure of engagement with the intervention. The measures used for this study are described in more detail below.

6.3.8.1 Demographic characteristics

Socio-demographic characteristics, including gender, age, ethnic origin and qualification, were obtained from health records. Age was categorised as adult (18 to 65 years old) or older adult (>65 years old). Ethnic origin was categorised as white (white British, white Irish or other white background) or other (African, other black background, Indian, Pakistani, Bangladeshi, Chinese, other Asian background, white and black Caribbean, white and Asian, other mixed background or other ethnic origin). Qualification was categorised as non-degree (GCSE/School certificate/O-level/CSE, Vocational qualifications or A-level or equivalent); degree (degree or post-graduate degree) or; other (still studying, other or do not wish to answer).

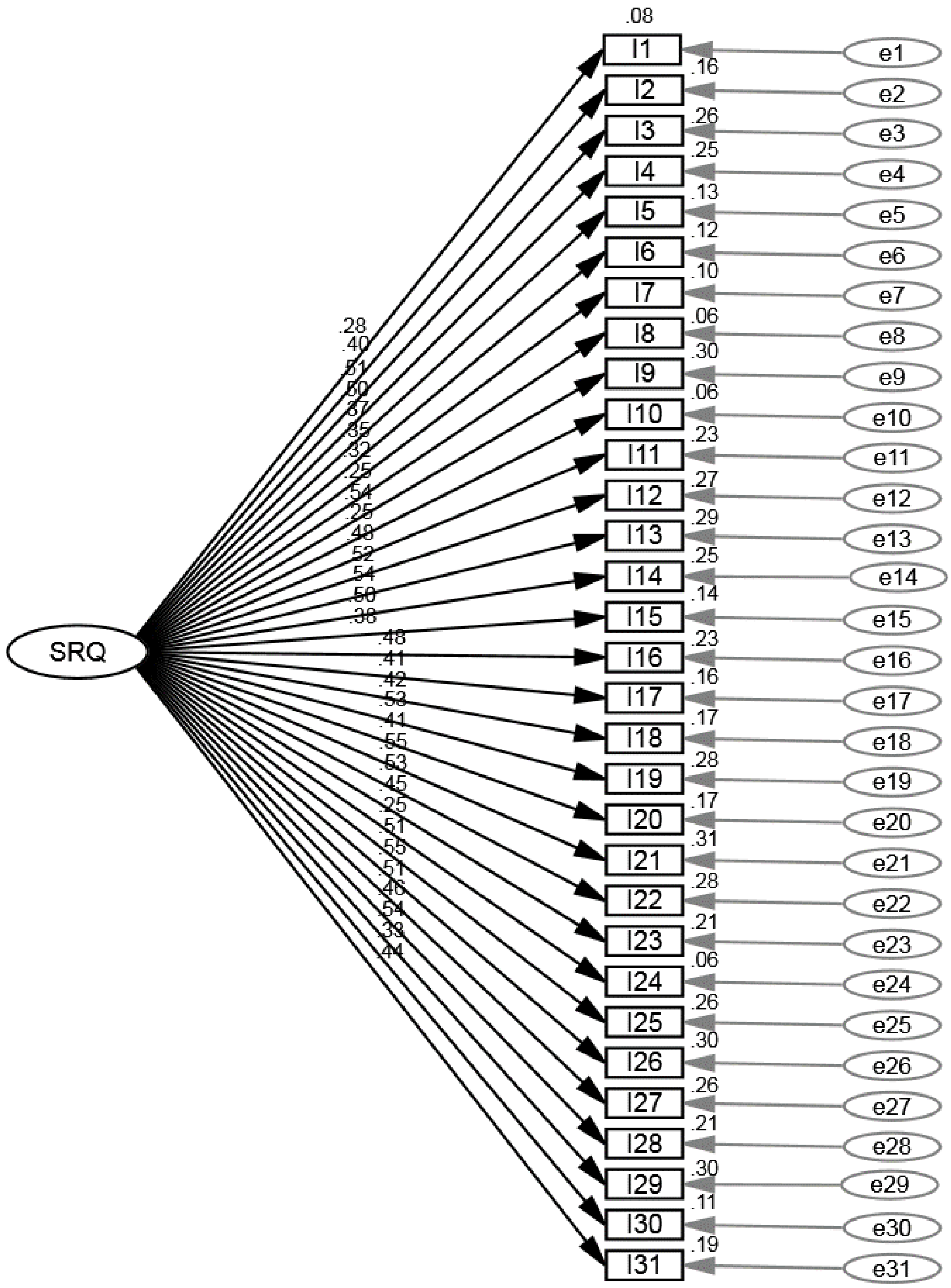
6.3.8.2 Anthropometric measures

Body weight (in kg) was taken using TANITA scales supplied to the practices for use only in this study, and height (in cm) was taken using the practice equipment. Body Mass Index (BMI) was calculated by dividing weight (kg) by height (m) squared. BMI was then categorised according to the grade of obesity (England, 2012): grade 1 (30-34.9 kg/m^2), grade 2 (35-39.9 kg/m^2) and grade 3 (>40 kg/m^2).

6.3.8.3 Self-regulatory skills

Self-regulatory skills were assessed using the validated 31-item Self-Regulation Questionnaire- SRQ (Carey et al., 2004), discussed in Chapter 4, adapted for eating and weight self-regulatory skills (see Appendix 6.6). This was due to there being no available questionnaire specifically assessing self-regulation of eating behaviour when the trial was designed. The adaptation consisted of changing the wording to make the items apply specifically to weight self-regulation. For example, 'I'm able to accomplish goals I set for myself' was changed was changed to 'I'm able to accomplish weight loss goals I set for myself'. The response scale was also changed from a 5-point Likert scale to 4-point Likert scale (strongly disagree to strongly agree), removing the original option 'uncertain or unsure', in order to encourage people to commit one way or the other. The scores ranged from 1 to 4. I have used the baseline data from the adapted questionnaire to assess its internal reliability, which was shown to be adequate (Cronbach's alpha of 0.88). Since the original SRQ had a single factor structure, I also performed a Confirmatory Factor Analysis (CFA) in order to confirm this structure in the adapted version. It is recommended that several goodness of fit statistics are used to assess how well the model fits the data (Thompson, 2004). The indices used to assess the model fit were the same as described in Study 1 (Chapter 4), that is: i) Chi-square should be non-significant; ii) Normed Fit Index (NFI) and Comparative Fit Index (CFI) should be closer to 1 (Dugard et al., 2010); iii) Root-Mean-Square Error Approximation (RMSEA) should be <0.1 (Dugard et al., 2010). Figure 6.1 shows the results from the CFA. The Chi-square results were significant (df=434; x^2=2470.304; p<0.001). However, other model fit indices showed a somewhat good fit: NFI= 0.50; CFI= 0.54 and RMSEA= 0.07. All the regression coefficients were greater than 0.25 and no modifications to the model were performed, demonstrating that the model fitted the data.

Figure 6.1 One-factor confirmatory factor analysis model for SRQ adapted for weight and diet (N=513)



Note= Values over the arrow are the regression coefficients (Beta values). Values over the observed variables are the R^2.

6.3.8.4 Behavioural measures

The 10TT intervention targeted 10 eating and activity behaviours plus self-weighing behaviour. To assess these behaviours one item taken from the 12-item Self-Report Habit Index (Verplanken & Orbell, 2003) was used, which asks the frequency of carrying out a behaviour over the previous two weeks. For some of the target behaviours more than one frequency question was generated to better assess the adherence to the behaviour. For example, for 'look at labels' behaviour, two questions on the frequency of how people look at labels when preparing food and when buying food were generated. In total, 16 questions asked the frequency of carrying out each of the target behaviours over the previous two weeks, on a 5-point Likert scale, from 'none of the time' to 'all of the time' (see Appendix 6.7). The scores ranged from 1 to 5. The overall mean score for the 16 behaviours was calculated as well as the mean change from baseline to 3-month follow-up.

In order to look in more detail at the impact of the intervention on eating behaviours, valid measures of dietary intake were used. Fat intake was assessed using the dietary fat scale from the validated Dietary Instrument for Nutrition Education (DINE), a brief food frequency questionnaire that has good agreement with food diaries (Roe, Strong, Whiteside, Neil, & Mant, 1994). A score was allocated to each response option following the questionnaire's published scoring guidelines. Total score was then calculated. Fruit and vegetable intake (F&V) was assessed using an adapted version of the 2-item food frequency questions used in Study 1 and 2 (Chapter 4 & 5), in which participants reported their intake on a 7-point response scale that ranged from 1 (less than 1 portion per week) to 7 (3 or more portion per day) (Cappuccio et al., 2003). Participants also answered two questions on the frequency of sweet snacks (SS) intake, such as chocolates, sweets biscuits, cakes, buns, pastries and ice-cream intake. Additionally, four items assessed the frequency of sugary drinks intake (SD), such as non-diet fizzy drinks, fruit juices, sugar-containing squashes, milkshakes and hot chocolate. The response options ranged from 1 (never/ rarely) to 7 (3 or more times a day). Following Mcgowan et al (2012), answers were recoded to represent daily intake, for example, '2-3 times a week' was coded as 0.36. The mean score for the frequency F&V, SSS and SD were calculated as well as the mean change from baseline to 3-month follow-up.

6.3.8.5 Engagement with the intervention

Participants were provided with log books, these had tick sheets for participants to record, on a daily basis, whether they managed each tip and also record their weight. These also included a space for notes and weekly planning sheets, where participants could write down how they aimed to achieve each tip. Participants were asked to return their log books after 3 months. The data available from the log books included: the number of weeks that pages for self-monitoring, weight recording and planning were used, the total number of times overall target behaviours were achieved at least 5 times per week and the average number of tips managed per week.

6.3.9 Statistical analyses

All analyses were conducted on intention-to-treat basis, which means that participants were analysed in the groups they were originally randomly assigned (Hollis & Campbell, 1999). Since full intention to treat analysis is only possible when complete data are available for all participants, both completers and sensitivity analyses were performed.

Initially a completer analysis was performed using complete data at baseline and follow-up for each outcome. Participants with more than 20% of missing data at baseline for the self-regulation and target behaviours questionnaires and with any missing data for dietary intake questions were excluded from the analyses. When there was up to 20% missing data for the self-regulation and target behaviours questionnaires, the individual median score was imputed.

Assumptions of normality were assessed by visual inspection, using histograms and P-P plots, and also by statistical parameters such as median, mean, skewness and kurtosis. For medium sample sizes (~300), a cut-off point of absolute skewness >2 and kurtosis >7 is recommended (as cited in Kim, 2013). Outliers were identified using standardized values. An absolute z value greater than 3.29 was considered an outlier. Analyses without the outliers were performed, but results are reported only when they differ from the analyses with the outliers. For the majority of the analyses the 95% confidence interval was generated using bootstrapping to reduce potential bias.

Descriptive analyses were used to characterise the sample by study arm, including information on socio-demographics, weight, self-regulation score, target behaviours and dietary intake. To explore baseline differences between the completers and non-completers at 3 months for each of the primary and secondary outcomes, Chi-square tests for categorical variables and t-tests or Mann-Whitney tests for continuous variables were applied.

Analyses testing for intervention efficacy took clustering by practice into account (Beeken et al., 2017). For the current study, clustering effects were tested by running unconstrained models in the mixed effect models and calculating the intracluster correlation coefficients (ICC). As the ICC for all models was lower than 0.05, the observations within clusters were deemed no more similar than observations from different clusters. For that reason, simpler analysis techniques not accounting for clustering were used here.

Changes in self-regulatory skills within each randomisation group were assessed using paired t-tests. For the between-group analyses, t-tests (unadjusted model) and ANCOVAs (adjusted model controlling for age, gender and baseline self-regulation and weight) were used. Regression models were used to explore whether baseline self-regulatory skills predicted the effect of the intervention on self-regulatory skills at 3-month follow-up. The model was adjusted for age, gender and baseline weight and included an interaction term (group condition by predictor). The assumptions of homogeneity of variances and homogeneity of regression slopes and normality of residuals were checked.

The effect of 10TT on target behaviours and dietary intake were also explored. Paired t-tests were used to examine within-group changes for each of the behaviours over 3 months. As above, between-group differences were assessed using t-tests (unadjusted models) and ANCOVA (adjusted models, controlling for baseline levels of each variable, age, gender and baseline weight). Separate models were run for each outcome.

The mediation effects of mean change in self-regulation on the relationship between group condition and changes in behaviours at the 3 month follow-up were tested using bootstrapping to estimate indirect effects, and the Sobel test. However, the mediation analyses were only performed for the behaviours that showed significantly different changes between the 2 groups. As previously described, the primary results for the trial showed that the 10TT intervention promoted a significantly greater weight loss compared to the usual care group at 3-month follow-up. Therefore, the mediation effects of self-regulatory mean changes on the relationship between group condition and weight loss over 3 months were also tested. The method used for the mediation analysis was the Baron and Kenny (1986) approach, in which the paths of the mediation model are estimated through a series of regression analyses. The Sobel test, also called the *product-of-coefficient*, has been widely used in the literature for estimating the indirect effect, but is also considered a conservative method. For that reason, Preacher and Hayes (2008) also recommend using bootstrapping for testing indirect effects. Bootstrapping is a method that does not impose normality of the sampling distribution and involves multiple resampling of the data set, estimation of the indirect effects and the construct of the confidence interval for the indirect effect (Preacher & Hayes, 2008). All mediation analyses were performed using Process by Andrew F. Hayes in SPSS and adjusted for gender, age and baseline data for each outcome. Indirect effects were calculated for the total effect and for each mediator. A 95% Bias Corrected Bootstrapped Confidence Interval was calculated for each indirect effect.

To build on the mediation analyses, a path analysis was conducted using Structural Equation Modelling (SEM). This allowed the mediation process to be expanded to include multiple independent variables in order to provide a better understanding of the pattern of relationship between group conditions, self-regulatory skills, target behaviours and weight loss. Standardised direct, indirect and total effect of group condition, self-regulatory skills changes and target behaviour changes on weight loss were estimated. Pathways were established based on the hypothesis for this study, as well as on the ANCOVA and mediation results. Models were fitted by the maximum likelihood method. Confidence intervals were calculated by the bootstrap with 1000 resamples of patients. The model fit was considered satisfactory when the following criteria were met: non-significant Chi-square, Normed Fit Index (NFI) and Comparative Fit Index (CFI) closer to 1 (Dugard et al., 2010) and Root-Mean-Square Error Approximation (RMSEA) lower than 0.1 (Dugard et al., 2010).

Finally, descriptive analyses of the use of the 10TT log books in relation to the level of change in self-regulatory skills, weight and target behaviours over 3 months were explored using ranked percentiles: percentile <75 represented medium to small changes and percentile ≥75 represented large changes. Baseline differences were compared in those who sent back the log book and those who did not, using Chi-square tests for categorical data and t-tests for continuous data.

Following the planned analyses published in the protocol for the 10TT trial (Beeken et al., 2012), sensitivity analyses were performed to investigate the potential effect of missing responses for the outcomes. Multiple imputations were applied to replace missing data at baseline and follow-up for all outcomes. Multiple imputation models were stratified by study arm and included socio-demographics, self-regulation, target behaviours, dietary intake and weight data. A set of 100 imputations were performed.

Data were analysed using SPSS version 24.0 (SPSS Inc), but for the SEM analyses the SPSS/AMOS version 24.0 (SPSS Inc) was used. Taking into account the multiple testing performed in this study, statistical significance was defined as a value of $p \leq 0.01$.

6.3.10 Ethical approval

As described in the protocol (Beeken et al., 2012), the study obtained ethical approval from the South East London Research Ethics Committee 2 via IRAS (Ref No. 10/H0802/59, approval granted 9th July 2010). The other participating centres provided site-specific approval as per usual IRAS procedures. This study received NHS Research and Development (R&D) approval from all participating NHS Boards prior to the start of the trial. The trial was prospectively registered with the International Standard Randomised Controlled Trials (ISRCTN16347068). All participants gave informed consent.

6.4 Results

6.4.1 Participants flow and characteristics

A total of 568 patients were assessed for eligibility, 31 were excluded because they had a BMI<30 kg/m^2 (N=23), did not want to take part (N=1) or for other reasons (N=7). A total of 537 obese patients were eligible to take part in the study; 267 were randomised to the intervention group and 270 to the control group.
Figure 6.2 displays the flow diagram of study participation during the first 3 months of the trial.

Figure 6.2 Flow diagram of participation during the 3-month study period

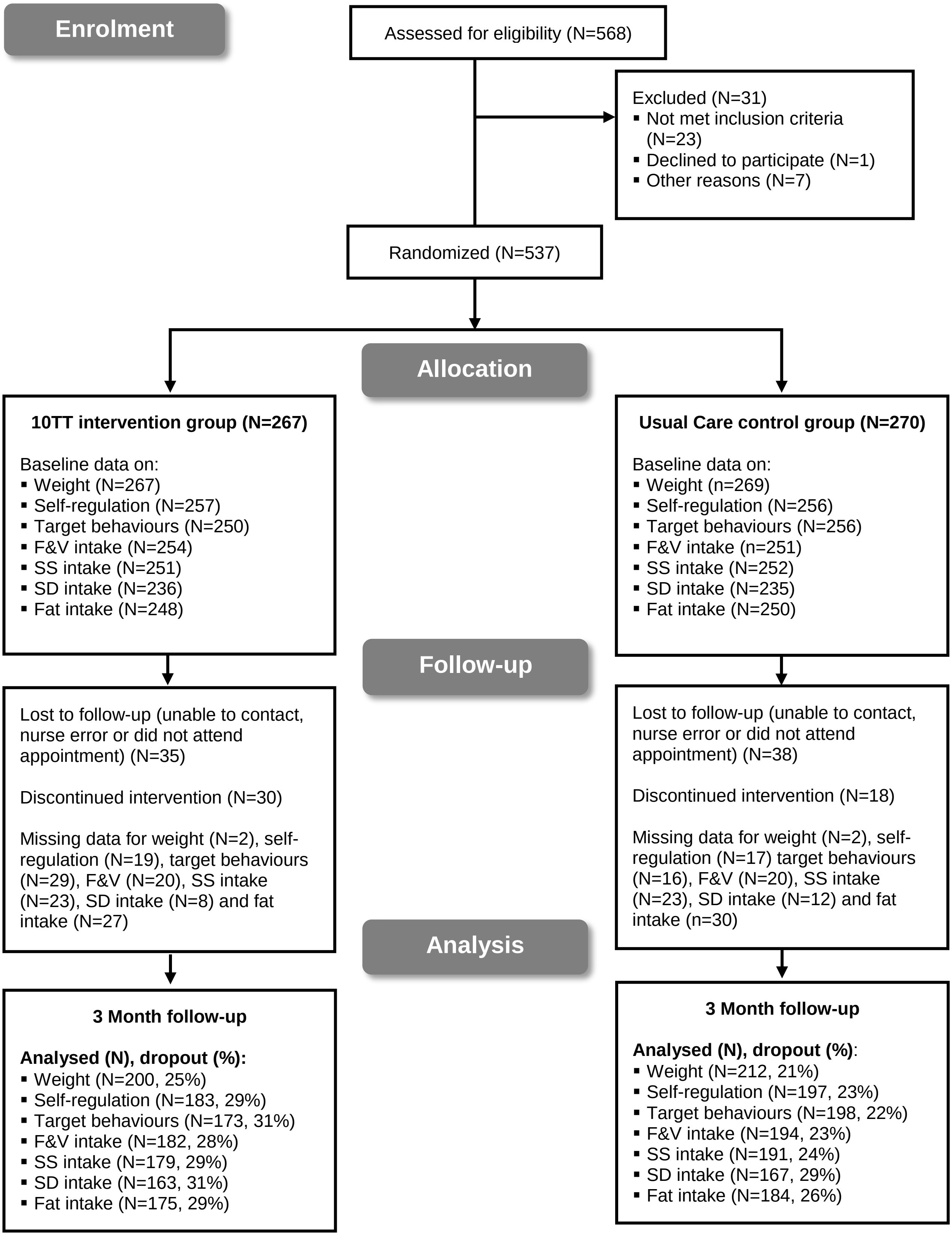


Table 6.2 shows the baseline characteristics of the participants, which appeared similar in the two study arms. Approximately two thirds of the participants were female (~65%), most were white (~95%), and approximately half did not have a degree (~47%). Mean age was 57.3 and mean BMI was 36.3 kg/m^2. Self-regulation, target behaviours and dietary intake were similar between the two arms.

Table 6.2 Baseline characteristics by randomised group

Characteristics	Intervention group (N=267)	Control group (N=270)
Age (in years)		
Mean (sd)	57.0 (12.8)	57.6 (12.5)
Gender		
Female, % (N)	66.7 (178)	64.8 (175)
Ethnic group		
White[a], % (N)	94.7 (252)	95.2 (255)
Other[b], % (N)	5.3 (15)	4.9 (13)
Qualification		
Non-degree[c], % (N)	49.6 (129)	44.4 (116)
Degree[d], % (N)	28.8 (75)	34.9 (91)
Other[e], % (N)	21.5 (56)	20.7 (54)
Weight (in kg)		
Mean (sd)	100.4 (17.0)	101.4 (17.9)
BMI[†] (in kg/m^2)		
Mean (sd)	36.1 (4.7)	36.5 (5.4)
Self-regulation[g]		
Mean (sd)	2.4(.3)	2.4 (.3)
Target behaviours[h]		
Mean (sd)	3.1 (.5)	3.2 (.5)
Fruit & Vegetables[i]		
Mean (sd)	1.76 (1.0)	1.77 (1.0)
Sweets Snacks[j]		
Mean (sd)	.46 (.5)	.38 (.4)
Sugary drinks[k]		
Mean (sd)	1.90 (.84)	1.86 (.75)
Fat intake[l]		
Mean (sd)	44.7 (14.8)	42.7 (13.4)

Note= [a]White British, White Irish or other White background. [b]African, other black background, Indian, Pakistani, Bangladeshi, Chinese, other Asian background, White and Black Caribbean, White and Asian, other mixed background or other ethnic origin. [c]GCSE/School certificate/O-level/CSE, Vocational qualifications or A-level or equivalent. [d]Degree or Post-graduate degree. [e]Still studying, other or do not wish to answer. [F]BMI= Body Mass Index. [g]Self-regulatory skills score ranged from 1 (strongly disagree) to 5 (strongly agree). [h] Overall mean score for the frequency of doing the 16 target behaviours, it ranged from 1 (none of the time) to 5 (all of the time). [i]Fruit & vegetable intake in servings per day. [j]Daily occasions of sweet snacks intake. [k]Daily occasions of sugary drinks intake. [l]Score for the DINE questionnaire - Cut offs: <30 low fat; 30-40 medium fat; >40 high fat. sd=Standard deviation.

A total of 380 participants provided data on self-regulation at both baseline and 3 months (post-intervention). The non-completers were not significantly different at baseline in socio-demographic characteristics, weight, self-regulation, target behaviours and dietary intake from those who provided data at both time points (see Table 6.3). The only exception was age, which was significantly greater among completers than non-completers (p=.002).

Table 6.3 Baseline characteristics by completers and non-completers for self-regulatory skills

Characteristics	Self-regulatory skills: Completers (N=380)	Self-regulatory skills: Non-completers (N=157)	Statistics
Age (in years)			
Mean (sd)	58.5 (11.7)	54.3 (14.4)	t(245.4)=3.210, *p*=**.002**
Gender			
Female, % (N)	64.5 (245)	68.8 (108)	$X^2(1)=.91$, *p*=.338
Ethnic group			
White[a], % (N)	95.3 (362)	92.9 (145)	$X^2(1)=1.15$, *p*=.282
Other[b], % (N)	4.7 (18)	7.1 (11)	
Qualification			
Non-degree[c], % (N)	46.2 (172)	49.0 (73)	$X^2(2)=2.73$, *p*=.254
Degree[d], % (N)	33.9 (126)	26.8 (40)	
Other[e], % (N)	19.9 (74)	24.2 (36)	
Weight (in kg)			
Mean (sd)	100.7 (16.7)	101.3(18.9)	t(534)=-.365, *p*=.715
BMI[†] (in kg/m^2)			
Mean (sd)	36.2 (4.9)	36.5 (5.4)	
Median (IQR)	34.9 (32.6; 39.0)	35.0 (32.5; 39.3)	Mann Whitney=.687
Self-regulation[g]			
Mean (sd)	2.4 (.3)	2.4 (.3)	t(511)=.276, *p*=.783
Target behaviours[h]			
Mean (sd)	3.2 (.5)	3.1 (.5)	t(504)=1.286, *p*=.199
Fruit & Vegetables[i]			
Mean (sd)	1.83 (1.0)	1.60 (1.1)	t(503)=2.161, *p*=.031
Sweets Snacks[j]			
Mean (sd)	.40 (.44)	.46 (.53)	
Median (IQR)	.25 (.08; .57)	.35 (.14; .53)	Mann Whitney=.270
Sugary drinks[k]			
Mean (sd)	1.87 (.78)	1.91 (.84)	t(469)=-.384, *p*=.701
Fat intake[l]			
Mean (sd)	43.8 (13.7)	43.4 (15.1)	t(496)=.297, *p*=.766

Note= [a]White British, White Irish or other White background. [b]African, other black background, Indian, Pakistani, Bangladeshi, Chinese, other Asian background, White and Black Caribbean, White and Asian, other mixed background or other ethnic origin. [c]GCSE/School certificate/O-level/CSE, Vocational qualifications or A-level or equivalent. [d]Degree or Post-graduate degree. [e]Still studying, other or do not wish to answer. [F]BMI= Body Mass Index. [g]Self-regulatory skills score ranged from 1 (strongly disagree) to 5 (strongly agree). [h] Overall mean score for the frequency of the 16 target behaviours, it ranged from 1 (none of the time) to 5 (all of the time). [i]Fruit & vegetable intake in servings per day. [j]Daily occasions of sweet snacks intake. [k]Daily occasions of sugary drinks intake. [l]Score for the DINE questionnaire - Cut offs: <30 low fat; 30-40 medium fat; >40 high fat. sd=Standard deviation. IQR= Interquartile range.

Regarding the overall target behaviours, completers showed similar baseline characteristics to non-completers (see Appendix 6.8), with the exception of age; completers were older than non-completers (t(271.7)=2.682, *p*=0.004). Additionally, completers and non-completers for the dietary behaviour outcomes (fruit and vegetables, sweet snacks, sugary drinks, and fat intake) had similar baseline characteristics (see Appendix 6.9). However, completers for fruit and vegetable (*p*=0.001) and sweet snacks (*p*=0.01) intake were older.

6.4.2 Post-intervention effect on self-regulatory skills

As shown in Table 6.4, self-regulatory skills increased significantly over 3 months in both groups (*p*<0.001 for all analyses), but the change was greater in the intervention group. The between-group analyses showed that at the 3 month follow-up, participants who were given the 10TT intervention had a mean change in self-regulatory skills of .08 (adjusted 95%CI 0.01; 0.15, *p*=.01) greater than those who received Usual care. Change in self-regulatory skills in the 10TT group represented a medium effect size (d=0.5) and in the Usual care group a small effect size (d=0.3). However, the effect size of this difference was small (partial n^2= 0.015). Sensitivity analysis using multiple imputations gave similar results.

Regression models adjusted for age, gender and baseline weight indicated that lower baseline self-regulatory skills predicted greater changes in self-regulation (β=-0.22 se=0.06, *p*<0.001) at 3 month follow-up. This did not differ by study arm, as no interaction between baseline data and group condition was found. Analyses using multiple imputations mirrored the results found for completers.

Table 6.4 Effect of the 10TT intervention on self-regulation at 3-month follow-up

Characteristics	**Intervention group**					**Control Group**					**Unadjusted mean diff (95%CI)**	**Adjusted**$^{\Delta}$ **mean diff (95%CI)**
	N	**Baseline** M (se)	**3M** M (se)	**Diff** (95%CI)	**d¥**	N	**Baseline** M (se)	**3M** M (se)	**Diff** (95%CI)	**d¥**		
Completers												
Self-regulation[a]	183	2.46(.02)	2.68(.03)	.22(.16;.27)**	.5	197	2.49(.02)	2.62 (.03)	.12(.08;.17)**	.3	.09(.02;.16)*	.08 (.01;.15)*
Sensitivity analyses[b]												
Self-regulation[a]	267	2.46(.02)	2.68(.03)	.21(.16;.26)**	.5	270	2.49(.02)	2.61 (.03)	.12(.07;.17)**	.3	.09 (.02;.15)*	.08 (.01;.14)*

Note= [a]Self-regulatory skills score ranged from 1 (strongly disagree) to 5 (strongly agree). [b]Sensitivity analysis using multiple imputation to deal with missing data. $^{\Delta}$Adjusted for gender, age, baseline weight and baseline data for self-regulation. ¥Cohen's d effect size. M= Mean. se= standard error. 95%CI=95% confidence interval. $^{**}p \leq .001$ $^{*}p \leq .01$

6.4.3 Post-intervention effect on target behaviours and the relationship with self-regulation

Table 6.5 shows the mean scores for each of the target behaviours at baseline and 3 months, by group condition. Although the frequency varied according to the target behaviour, the pattern of changes was similar within each group condition.

Table 6.5 Mean scores for each target behaviours at baseline and 3 months, by group condition

Target behaviour	Intervention group				Control group			
	Baseline		3 months		Baseline		3 months	
	N	M(sd)	N	M(sd)	N	M(sd)	N	M(sd)
1. Keep to your meal routine[a]	254	3.6(.9)	188	4.0(.7)	258	3.8 (.7)	208	3.9 (.6)
2. Go reduced fat[b]	257	3.0(.8)	188	3.5(.7)	260	3.2(.7)	208	3.4(.7)
3. Walk off the weight[a]	255	2.2(1.5)	183	2.3(1.3)	253	2.3(1.6)	199	2.4(1.4)
4. Pack a healthy snack[a]	240	3.2(.9)	172	3.8(.8)	244	3.2(.9)	192	3.7(.8)
5. Look at the labels[b]	251	2.8(1.1)	185	3.6(1.0)	255	2.9(1.1)	202	3.3(1.0)
6. Caution with your portions[b]	259	3.6(.9)	189	4.1(.7)	262	3.6(.9)	208	4.0(.7)
7. Up on your feet[a]	257	3.6(1.1)	189	4.0(.9)	260	3.6(1.1)	206	3.8(.9)
8. Think about your drinks[b]	251	3.9(.9)	158	4.2(.8)	255	3.9(.8)	207	4.1(.8)
9. Focus on your food[b]	261	3.4(1.1)	191	3.7(1.0)	262	3.4(1.0)	210	3.5(1.0)
10. Don't forget your 5-a-day[a]	261	2.7(.9)	191	3.1(.9)	260	2.8(1.0)	209	2.9(1.0)
Record your weight[a]	261	1.1(1.3)	215	2.4(1.8)	264	1.1(1.3)	229	1.5(1.3)

Note= Frequency score to each of the target behaviours ranged from 1 (none of the time) to 5 (all of the time).
[a]Mean score based on one question. [b]Mean score based on two questions. M= mean. sd= Standard deviation.

As shown in Table 6.6, over 3 months the mean score for the target behaviours increased .46 (p<.001) in the 10TT group and .26 (p<.001) in the usual care group. These changes were found to be significantly greater in the 10TT group compared to the usual care group (mean difference=.20, 95%CI 12.;.29), representing a medium-sized effect (partial n^2=.06). Results for the sensitivity analyses were in line with the completers' results.

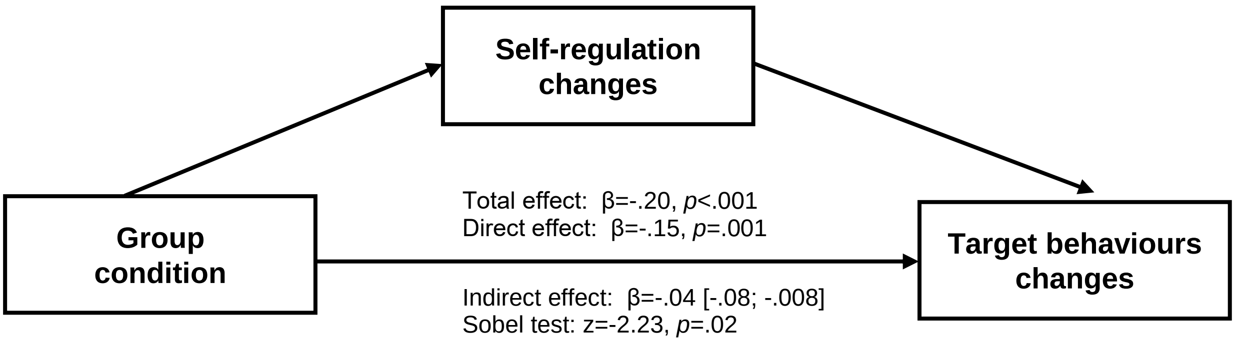
Table 6.6 Effect of the 10TT intervention on overall target behaviours at 3-month follow-up

	Intervention group					Control Group						
Characteristics	N	**Baseline** M (se)	**3M** M (se)	**Diff** (95%CI)	**d[¥]**	N	**Baseline** M (se)	**3M** M (se)	**Diff** (95%CI)	**d[¥]**	**Unadjusted Mean diff (95%CI)**	**Adjusted[Δ] Mean diff (95%CI)**
Completers												
Target behaviours[a]	173	3.2 (.03)	3.7 (.03)	.47(.39;.54)**	.7	198	3.21(.03)	3.5 (.03)	.26(.20;.33)**	.5	.20(.10;.30)**	.20(.12;.29)**
Sensitivity analyses[b]												
Target behaviours[a]	267	3.1(.03)	3.6(.03)	.46(.54;12.6)**	.9	270	3.2(.03)	3.4(.03)	.25(.18;3.12)**	.6	.23(.13;.32)**	.20(.12;.29)**

Note= [a]Target behaviours score ranged from 1 (none of the time) to 5 (all of the time), overall mean for the 16 behaviours. **[b]**Sensitivity analysis using multiple imputation to deal with missing data. **[Δ]**Adjusted for gender, age, baseline weight and baseline data for target behaviours. [¥]Cohen's d effect size. M= Mean. Se= standard error. 95%CI=95% confidence interval. ***p*≤.001. **p*≤.01.

The present study also assessed whether self-regulatory skills changes were the underlying mechanism through which 10TT promoted increases in the target behaviours. Mediation analysis was applied, controlling for gender, age, baseline weight and baseline data for target behaviours. Figure 6.3 shows that there was a significant effect of the intervention on the target behaviours at 3 month-follow-up through changes in self-regulatory skills (β=-0.04, Bias Corrected 95%CI -0.08; -0.008). Self-regulatory skills changes mediated part of the effect of group condition on target behaviours, since there was still some residual direct effect even after introducing the mediator into the model (β=-0.15, *p*=0.001). The sensitivity analyses using multiple imputations showed similar results (z=-2.82, *p*=0.004).

Figure 6.3 Mediation of self-regulation changes on the effect of group condition on target behaviours changes at 3-month follow-up



Note= *Estimates adjusted for age, gender and weight at baseline, self-regulation at baseline and target behaviours at baseline. Group condition: 10TT=0 & Usual care=1. Indirect effect assessed using bootstrapping.

6.4.4 Post-intervention effect on dietary intake and its relationship with self-regulation

Table 6.7 shows the effect of the 10TT on F&V, SS, SD and Fat intake over 3 months. Within-group analyses suggested that over 3 months there was a significant increase in F&V intake in both groups (*p*<0.001), representing a medium effect size (d=0.5) in the 10TT group and a small effect size (d=0.2) in the Usual care group. Both groups significantly decreased their consumption of SS at 3-month follow-up (p<0.001) representing a medium-sized (d=0.4). Fat intake also decreased significantly in both groups (p<0.001), however a medium effect size (d=0.5) was seen in the 10TT group and a small effect size (d=0.3) in the Usual care group. Regarding the consumption of SD, it decreased significantly in the 10TT (p<0.01), representing a small effect-sized (d=0.2), but no effect was observed in the Usual care group over 3 months. Sensitivity analysis showed similar results.

Between-group analyses indicated that daily servings of F&V intake increased 0.24 (95%CI 0.07; 0.40, *p*=0.005) more in the 10TT group than in the Usual care group. However, the effect size of this difference was small (partial n^2=0.02). Fat score decreased 2.30 (95%CI -4.4; -0.17, *p*=0.031, partial n^2=0.01) more in the 10TT group compared to Usual care, but this difference did not reach the cut-off point for significance for this study (*p*≤0.01). Additionally, sensitivity analyses for the adjusted between-group difference for fat intake score was not statistically significant (adj mean diff=-2.0, 95%CI -4.2; 0.009). With respect to occasions of SS and SD consumption, no significant differences between groups were found, even after imputing missing data.

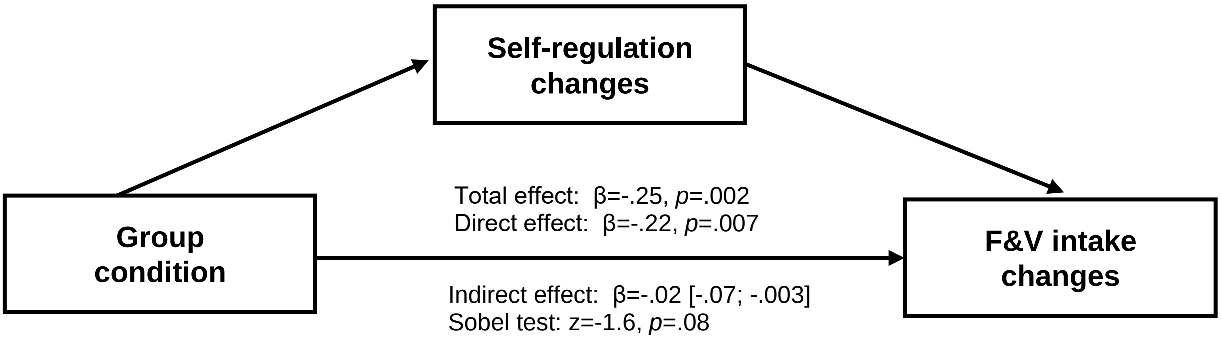
Table 6.7 Effect of the 10TT intervention on dietary intake at 3-month follow-up

Characteristics	Intervention group					Control Group					Unadjusted mean diff (95%CI)	Adjusted[Δ] mean diff (95%CI)
	N	Baseline M (se)	3M M (se)	Diff (95%CI)	d[¥]	N	Baseline M (se)	3M M (se)	Diff (95%CI)	d[¥]		
Completers												
F&V intake[a]	182	1.83(.07)	2.3(.07)	.46(.33;.58)**	.5	194	1.82(.07)	2.06(.07)	.24 (.10;.37)**	.2	.22(.03;.40)*	.24 (.07;.40)*
SS intake[b]	179	.44(.03)	.27(.02)	-.16(-.22;-.11)**	.4	191	.36(.02)	.24(.02)	-.11(-.16;-.05)**	.4	-.05(-.13;.02)	-.01(-.06;.05)
SD intake[b]	163	1.93(.06)	1.79(.06)	-.13(-.23;-.03)*	.2	167	1.82(.05)	1.79(.05)	-.03(-.12;.05)	.05	.-10(-.23;.03)	-.07(-.19;.04)
Fat intake[c]	175	44.2(1.0)	37.0(.95)	-7.1(-8.8;-5.4)**	.5	184	43.5(1.0)	39.0(.91)	-4.5(-6.3;-2.7)**	.3	-2.64(-5.1;-.16)	-2.30(-4.4;-.17)
Sensitivity analyses[2]												
F&V intake[a]	267	1.7(.06)	2.2(.06)	.45(.33;.57)**	.7	270	1.7(.06)	2.0(.06)	.23(.11;.36)**	.2	.24(.06;.42)*	.23(.06;.40)*
SS intake[b]	267	.47(.03)	.32(.02)	-.15(-.20;-.09)**	.4	270	.39(.02)	.28(.02)	-.10(-.15;-.05)**	.3	-.05(-.12;.02)	-.007(-.06;.05)
SD intake[b]	267	1.91 (.05)	1.82 (.04)	-.094 (-.18;-.01)*	.01	270	1.88 (.04)	1.85 (.04)	-.03(-.11;.05)	.05	-.10(-.23;.02)	-.102(-.22;.02)
Fat intake[c]	267	44.8(.9)	38.0(.9)	-6.86(-8.55;-5.16)**	.5	270	42.8(.8)	38.7(.8)	-4.1(-5.7;-2.4)**	.3	-2.96(-5.35;-.58)*	-2.0(-4.2;.009)

Note= [a]Fruit & vegetable intake in servings per day. [b]Daily occasions of sweet snacks and sugary drinks intake. [c]Score for the DINE questionnaire - Cut offs: <30 low fat; 30-40 medium fat; >40 high fat. [1]Sensitivity analysis using multiple imputation to deal with missing data. [Δ]Adjusted for gender, age, baseline weight and baseline data for the outcome. [¥]Cohen's d effect size. M= Mean. Se= standard error. 95%CI=95% confidence interval. ***p*≤.001. **p*≤.01.

Since a significant effect of 10TT was found for F&V intake, I assessed whether self-regulatory skills changes mediated this effect, when controlling for gender, age, baseline weight and baseline data for F&V and self-regulation. Figure 6.4 shows that there was a significant indirect effect (β=-.03, 95%CI -.07; -.005) of the 10TT intervention on F&V intake changes at 3 months mediated by changes in self-regulatory skills. Similar to the previous mediation results, self-regulatory skills were found to be a partial mediator. However, the Sobel test was non-significant (z=-1.8, p=.08), even when sensitivity analyses were performed (z=-1.93, p=.05).

Figure 6.4 Mediation of self-regulation changes on the effect of group condition on fruit and vegetable intake changes at 3-month follow-up

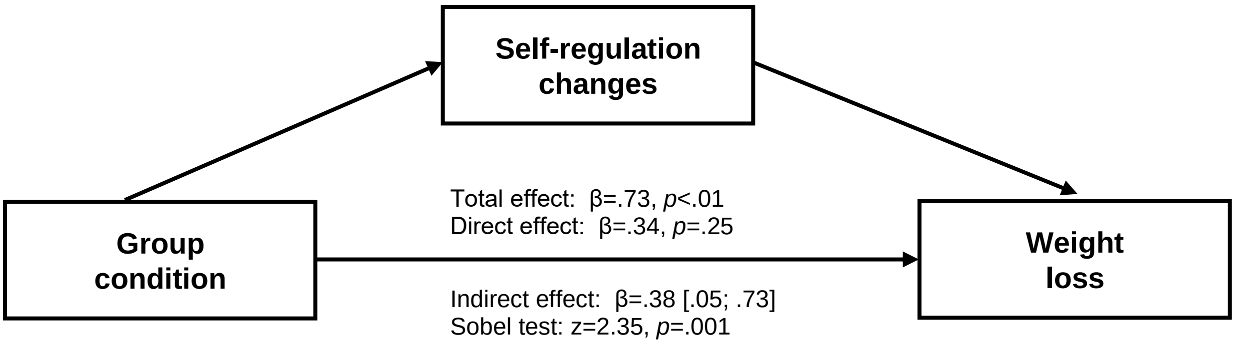


Note= *Estimates adjusted for age, gender and weight at baseline, self-regulation at baseline and F&V at baseline. Group condition: 10TT=0 & Usual care=1. Indirect effect assessed using bootstrapping.

6.4.5 Relationship between weight loss and self-regulation

Figure 6.5 shows the mediation effect of changes in self-regulatory skills on the relationship between the intervention and weight loss (Mean difference=.87, 95%CI -1.47; -.27) over 3 months. The 10TT significantly predicted self-regulation changes, which in turn significantly predicted weight changes at 3 months, when controlling for gender, age, baseline weight, and baseline self-regulation. The total effect was significant, while the direct effect was non-significant and indirect effect using bootstrapping was significant. The Sobel test was also assessed and was significant (z=2.35, *p*=0.010). Therefore, changes in self-regulatory skills mediated the effect of the intervention on weight change at 3-month follow-up. The sensitivity analysis using multiple imputations showed similar results (z=-2.86, *p*=0.004).

Figure 6.5 Mediation of self-regulation changes on the effect of group condition on weight loss at 3-month follow-up

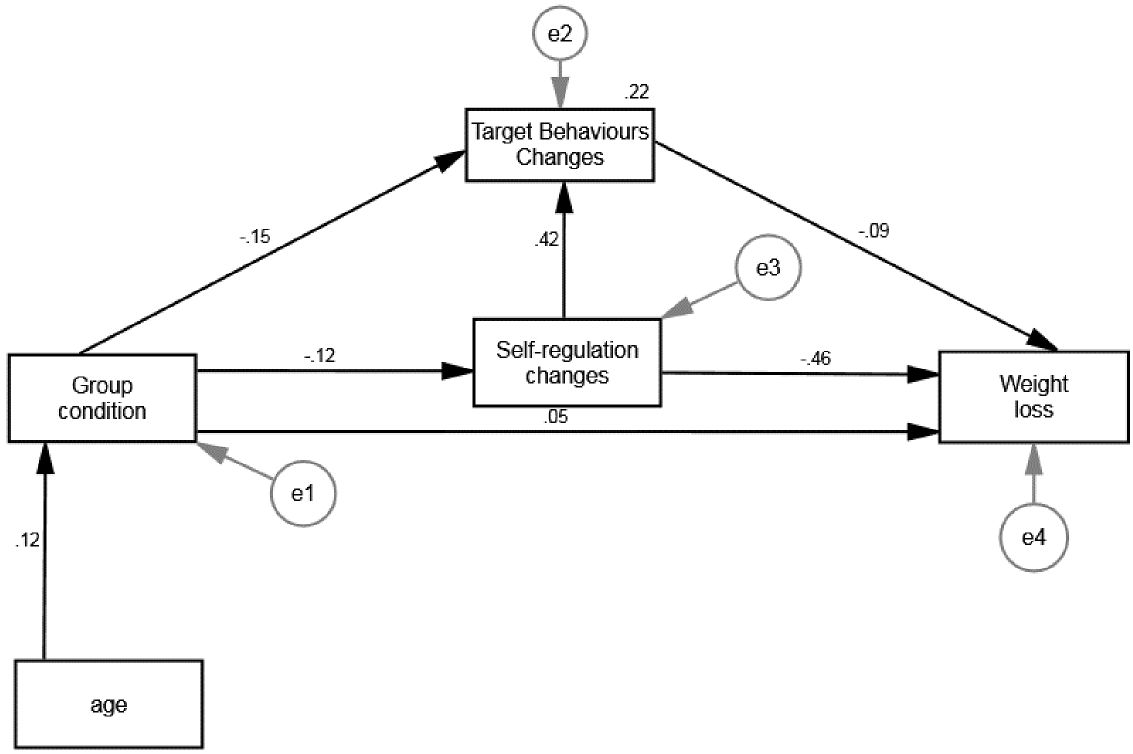


Note= *Estimates adjusted for age, gender and weight at baseline and self-regulation at baseline. Group condition: 10TT=0 & Usual care=1. Indirect effect assessed using bootstrapping.

6.4.6 Relationships between self-regulatory skills, weight and target behaviours

Path analysis assessing the relationship between self-regulatory skills, weight and target behaviours was applied using Structural Equation Modelling (SEM). Only participants with valid data for all variables were included in the model (N=335), as AMOS SPSS can only generate bootstrapping confidence intervals for completed data. Different solutions were assessed, and the final, best-fitting model is shown in Figure 6.6. The parameters of fit were χ^2 (3)=2.213, p=0.529; CFI=1.0; TLI=1.0; NFI=0.98; RMSEA=0.00.

Figure 6.6 Structural Equation Model of the effects of the10TT intervention on changes in self-regulatory skills, target behaviours and weight at 3-month follow-up



Note= Intervention:0 and Control:1. Values over the arrows represent standardized regression coefficients.

The model partially confirmed the study hypothesis. Table 6.8 shows that there was a significant indirect effect of group condition on weight loss through changes in self-regulatory skills and target behavious (BCa 95%CI 0.019; 0.131). However, the total effect of group on weight loss did not reach significance (BCa 95%CI -0.004; 0.22). The results also confirmed that group condition had a direct effect on self-regulatory skills (BCa 95%CI -0.232; -0.010), which in turn had a direct effect on weight loss (BCa 95%CI -0.554; -0.374). A partial mediation of self-regulatory skills changes on the effect of intervention on target behaviour changes (BCa 95%CI -0.101;-0.004) was also found. However, target behaviours changes did not have an effect on weight loss (BCa 95%CI -0.196; 0.033).

Table 6.8 Direct, indirect and total effect of the path analysis

(a) Exposure *(b) Mediator* (c) **Outcome**	Direct effect		Indirect effect		Total effect	
	β	95%CI	β	95%CI	β	95%CI
(a) Group condition *(b) Self-regulation changes & Target behaviours changes* (c) **Weight loss**	.046	(-.054;.139)	.074	(.019;.131)	.120	(-.004;.22)
(a) Group condition (b) *Self-regulation changes* (c) **Target behaviours changes**	-.147	(-.235;-.057)	-.051	(-.101;-.004)	-.198	(-.298;-.096)
(a) Group condition (c) **Self-regulation changes**	-.122	(-.232;-.010)			-.122	(-.232;-.010)
(a) Self-regulation (b) Target behaviours changes (c) **Weight loss**	-.464	(-.554;-.374)	-.037	(-.085;.014)	-.501	(-.568;-.420)
(a) Target behaviours changes (c) **Weight loss**	-.087	(-.196;.033)			-.087	(-.196;.033)

Note= β: standardised effects. 95%CI: Bias corrected 95% Confidence Intervals.

6.4.7 Descriptive analysis of engagement with the intervention

Table 6.9 presents the descriptive data from the returned 10TT log books. Around 40% of those who received 10TT returned the log books at 3 months. The baseline differences between those who sent back the log book did not differ from those who did not send it back (see Appendix 6.9). The majority of participants used the self-monitoring sheets correctly and for a median time of 13 weeks. However, those who showed the greatest changes in self-regulatory skills, target behaviours and weight used the self-monitoring sheet for around 14, 14 and 15 weeks, respectively. Most participants recorded their weight for around 13 weeks, but those with the greatest changes in weight recorded it for 15 weeks. In terms of planning, the majority of participants made plans to achieve their behavioural goals for around 10 weeks. However, those with the greatest increase in behavioural targets made plans for 11 weeks. People were asked to follow the 10 weight loss tips, however most managed five tips per week. People who showed the highest improvement in self-regulatory skills and weight loss managed around six tips per week and those with the greatest improvement in the frequency of the target behaviours managed seven tips per week.

Table 6.9 Descriptive data from the log books per level of changes in self-regulatory skills, target behaviours and weight over 3 months (Only 10TT participants)

Changes over 3 months	All 10TT participants[a]		10TT participants that returned the Log books[b]		Used self-monitoring sheets		Recorded weight		Made plans		N° times tips were managed ≥5 d/w	Tips managed per week
					Yes	N° weeks	Yes	N° weeks	Yes	N° weeks		
	N	M (sd)	% (N)	M (sd)	% (N)	MED	% (N)	MED	% (N)	MED	MED	MED
Self-regulation												
Per percentile[Δ]												
< 75	130	.03(.22)	38.4(50)	-.01(.21)	100(50)	13	90.0(45)	13	92.0(46)	10	76.5	5.5
≥ 75	53	.68(.27)	35.3(24)	.67(.24)	100(24)	14	91.6(22)	13	95.8(23)	10	92.0	6.5
Target behaviours												
Per percentile[Δ]												
< 75	115	.19(.32)	38.3(44)	.18(.36)	95.4(42)	13	90.9(40)	13	90.9(40)	10	76.5	5.5
≥ 75	58	1.0(.35)	43.1(25)	1.05(.40)	100(25)	14	88.5(23)	14	96.0(24)	11	99.0	7.5
Weight												
Per percentile[Δ]												
< 75	144	-.12(1.7)	35.4(51)	-.42(1.5)	96.1(49)	13	86.3(44)	12	92.2(47)	9	67.0	5.5
≥ 75	56	-5.7(2.7)	44.6(25)	-5.7(3.5)	100(25)	15	96.0(24)	15	96.0(24)	10	90.0	6.5

Note= [a]All 10TT participants with data for the outcome. [b]All 10TT participants who sent the log books back and had data for the outcomes. [Δ]Changes to the outcome over 3 months categorised according to the percentile, that is - <75= medium to low changes and ≥ 75= greater changes. M= mean. sd= Standard deviation. MED= Median. 3 months was equivalent to 15 weeks.

6.5 Discussion

This study is the first to explicitly assess the potential mechanisms of a brief habit-based intervention for weight loss in a population-based sample of adults with obesity. The study showed that 10TT promoted changes in self-regulatory skills and that these changes mediated the effect of 10TT on target behaviours and weight loss. Furthermore, participants who engaged more with the intervention in terms of number of weeks monitoring the target behaviours, recording weight, and making plans, experienced the greatest changes in self-regulatory skills, target behaviours and weight.

The results of this study are in line with the suggestion that habit-based interventions help people to improve their self-regulatory skills, since they require people to make goals, plan and monitor their behaviour (Lally & Gardner, 2013; Nederkoorn et al., 2010). This is consistent with other intervention studies that have applied planning techniques, where changes in self-regulatory skills were found over the short- (Kreausukon et al., 2012; Lange et al., 2013) and long-term (Luszczynska et al., 2007). However, this is the first study to show that a planning technique within a habit intervention improves self-regulatory skills. Importantly, the 10TT intervention was particularly effective at promoting self-regulatory skills among those patients who had poor self-regulation skills at baseline, although ceiling effects may have affected this result, since there was not much room for improvement among those who already had a high score in self-regulation. However, due to the nature of 10TT (a brief, self-help intervention), the specificity and relevance to weight loss of the goals and plans formed by the participants is not known. The quality of plans is relevant for habit formation, as they need to be context specific in order to promote long-term maintenance of the target behaviours changes. Future studies should assess the quality of plans made by participants and explore how this relates to habit formation and self-regulatory skills changes.

The target behaviours improved significantly more in the 10TT group compared to the usual care group. Overall, 10TT participants moved from performing the behaviours ‘some of the time’ to ‘most of the time’. Also, results showed that changes in self-regulatory skills mediated the effect of 10TT on the target behaviours. Self-regulatory skills are thought to help individuals to act according to an intended behaviour (Lally & Gardner, 2013; Nederkoorn et al., 2010) and by improving them, people would be more capable of making the behavioural changes. Given that the majority of studies do not assess the mechanism for an intervention’s success, this is an important finding which suggests the intervention works as it is intended to. This is also in line with recent evidence suggesting that nutrition and weight loss interventions that include self-regulation components tend to be more effective (Dombrowski, Knittle, Avenell, Araujo-Soares, & Sniehotta, 2014; Michie, Abraham, Whittington, McAteer, & Gupta, 2009).

Validated measures were used to explore in detail the effect of the intervention on dietary intake. Likewise, the 10TT intervention was more effective at improving fruit and vegetable consumption than usual care among participants with obesity, which was also mediated by self-regulatory skills changes. Other brief and face-to-face interventions have also found that enhancing self-regulatory skills promoted fruit and vegetable intake in the general adult population (Godinho, Alvarez, Lima, & Schwarzer, 2014; Lhakhang et al., 2014). Annesi and Mareno (2014) found similar results among adults with obesity (N=144) in the US, however they conducted a group-based intervention, which tend to be more intensive and time consuming. This is the first brief intervention with a habit-based approach conducted among adults with obesity in primary care that showed the effect of self-regulatory skills on fruit and vegetable intake. Since most of these studies looked only at the short-term effect (up to 6 months), future studies should investigate the impact of self-regulatory skills on the maintenance of higher fruit and vegetable intake.

The consumption of sweet snacks, sugary drinks and fat intake decreased significantly in the 10TT condition, but no difference between-groups was found. This was in line with Springvloet, Lechner, de Vries, and Oenema (2015) findings, which showed a significant decrease in saturated fat and sweet and salty snacks intake after a web-based intervention promoting self-regulatory skills among 1349 Dutch adults. However, similarly to the present study, no differences between intervention and control conditions were found. The authors argued that low engagement with the intervention may have affected the results, as even self-regulatory skills unexpectedly increased more in the control group than in the intervention. Regarding the 10TT intervention, the lack of intervention effect on unhealthy dietary intake may reflect the fact that the 10TT was designed to help people build new dietary habits. Even though building new habits could potentially help to break unhealthy ones, breaking habits require more effortful self-regulatory skills in order to disrupt cue-response associations (Lally & Gardner, 2013), suppress impulse tendencies toward temptations (Baumeister et al., 2006b) and prevent the loss of healthy habits when environmental cues change (Lally et al., 2008). Considering that higher self-regulatory skills have been related to lower sweet and salty snacks intake (Chapter 4 & 5), the inclusion of self-regulatory skills training specifically focused on breaking habits to the current advice on forming habits could potentially improve the effect of the intervention on unhealthy food intake.

According to the previous results of this trial, patients who received the 10TT also experienced greater weight loss than those who received usual care at 3 months. The present study also demonstrated that changes in self-regulatory skills mediated the effect of 10TT on weight loss at 3 months. However, since weight loss would likely happen as a result of dietary and activity behaviour changes, which in turn would require self-regulatory skills, path analyses were performed. The results were partially in line with what was expected. It showed that 10TT had an indirect effect on weight loss through changes in self-regulatory skills and target behaviours changes. However, only self-regulatory skills changes had a direct effect on weight loss, while changes in behaviours did not. However, these results should be taken with caution since only completed data for all variables were included, decreasing the power of the study to detect significant differences. Future studies powered to detect the mechanism of action of habit-based interventions on weight loss should replicate and build on this model.

Descriptive data for the engagement with the intervention indicated that participants who monitored their weight and target behaviours more frequently, and who made more plans, showed the greatest improvement in self-regulatory skills and target behaviours, and also experienced the greatest weight loss. This is an indication that the intervention worked best when engaged with. Although the difference in self-monitoring between those who showed the greatest and lowest changes in self-regulation was only around 1 week, this fits with self-regulation training evidence. A study conducted by Lange et al. (2013) showed that significant improvements in self-regulation can be observed over just a week. This is also in line with evidence showing that self-monitoring is a central BCT in weight management and nutrition interventions (Michie et al., 2009; Stubbs & Lavin, 2013). Future studies should explore ways to improve engagement, for example the use of novel technologies to facilitate self-monitoring.

6.6 Study Limitations

A strength of this study was that the intervention was delivered by health professionals from primary care across England, which provides direct evidence for its effectiveness in clinical practice. However, there are limitations concerning the generalisability of the results, which were presented with the previous findings from this trial (Beeken et al., 2017). Briefly, participants were not blinded to their condition, although the 3-month follow-up assessment was done by a health professional blinded to condition allocation. Ethnic minorities and men were under-represented and the sample was slightly older compared with the population of adults with obesity described in the Health Survey of England.

There are also limitations related specifically to the current analyses. The results for changes in self-regulation, target behaviours and dietary intake should be interpreted as exploratory, as the trial was only powered to detect differences in weight change between the group conditions. Self-regulation was measured using an adapted version of the SRQ and future studies should aim to replicate these analyses using a valid and reliable measure of eating self-regulatory skills, such as the recently developed Self-Regulation Questionnaire of Eating Behaviour (SREBQ) presented in Chapter 4.

Additionally, there are limitations related specifically to the measures used to assess the weight loss behaviours. The behaviours targeted by this intervention were measured using a single frequency item for each behaviour, which were combined to form a scale of the overall frequency of the target behaviours. However the validity and reliability of this scale is not known. Also, since the results for the valid and more detailed measures of dietary intake did not show big changes, it is possible that the target behaviour scale might have overestimated the effect of the intervention. The limitations of the dietary intake measures are the same as those discussed in previous chapters. The only difference was that instead of using one question to assess occasions of snacks and sugary drinks, this study used 2 and 4 questions, respectively. However, similarly to the previous studies within this thesis, the questions lacked portion size information. They also did not allow the calculation of overall energy intake. Similarly, fat intake was measured using a valid measure, but it only provided a score for fat intake and not the actual intake in grams or calories. This may have limited the accuracy of the data collected and the understanding of changes in dietary intake as well as their relationship with weight loss. As a retrospective measurement, these food frequency questionnaires also had the limitation of relying on individuals' memory. But their unannounced and self-administered features as well as the fact that they capture habitual behaviours are important strengths of these measures (Walton, 2015). Additionally, previous studies using these questions have showed that they seem to provide valid data on habitual dietary intake (Kliemann et al., 2016; McGowan et al., 2013). Furthermore, given the measures used in this study were all self-report, changes in self-regulatory skills, adherence and dietary intake may represent the individuals' perception of change, rather than actual change. Objective and technology-based methods to assess nutrition, physical activity and healthy behaviours could promote more accurate data on these behaviours (Bruening et al., 2016). Other aspects may have also played a role on the effect of the intervention on weight loss and target behaviours that were not included in these analyses. For example, social support has also been identified as an important aspect of behaviour change (Christakis & Fowler, 2007), and this should be further explored.

In addition, the analysis of the pathways was missing data for the variables of interest (compromising internal validity) and of course nullifying randomisation so that the results are more in keeping with that of a cohort study analysis than a RCT. Finally, qualitative analysis on the specificity of plans made by the participants and their relationship with habit formation could also further the understanding of the effect of this intervention.

6.7 Conclusions

In conclusion, this chapter's findings suggest that a habit-based intervention can enhance self-regulatory skills, especially among people with lower levels of self-regulatory skills at baseline. Furthermore, change in self-regulation is the underlying mechanism by which 10TT promoted improves target behaviours, and increases fruit and vegetable intake, which in turn promoted greater weight loss in adults with obesity, supporting the theoretical basis of the intervention. This study also provided evidence that greater engagement with the intervention was associated with greater improvements in self-regulatory skills, target behaviours and weight loss. Future studies should explore whether the effect of the 10TT intervention on self-regulation can be enhanced through facilitating engagement with the log books (e.g. through digital self-monitoring) and the effect of adding self-regulatory training for breaking existing habits on weight loss.

CHAPTER 7: DEVELOPMENT AND PRELIMINARY TESTING OF AN APP VERSION OF THE BRIEF HABIT-BASED WEIGHT LOSS INTERVENTION (STUDY 4)

7.1 Introduction

As discussed in the previous chapter, the 10TT habit-based intervention is effective at promoting weight loss and healthy behaviours through increases in eating self-regulatory skills. However, the paper format of the 10TT is becoming outdated. The use of new technology for lifestyle interventions is an emerging field in public health. Given the increased smartphone ownership in Britain (Ofcom, 2016), interest in developing lifestyle interventions using mobile apps has grown (Thomas & Bond, 2014). According to two meta-analyses, mobile app interventions led to significantly greater weight loss compared to control groups (Mateo, Granado-Font, Ferre-Grau, & Montana-Carreras, 2015; Schippers, Adam, Smolenski, Wong, & de Wit, 2017). The retention rates of weight loss interventions may also be greater using technology-based interventions compared to paper-based (Carter, Burley, Nykjaer, & Cade, 2013). However, most apps currently do not support habit formation (Klasnja, Consolvo, & Pratt, 2011) and those available for weight loss are not typically based on theory or evidence (DiFilippo, Huang, Andrade, & Chapman-Novakofski, 2015; Thomas & Bond, 2014).

Regarding the impact of mobile-based interventions on self-regulatory skills, the evidence is less clear since most studies have not used comprehensive measures to assess eating self-regulatory skills. The scoping review presented in Chapter 2 suggested that brief technology-based interventions using goal-setting, planning, self-monitoring, and feedback on performance techniques may potentially promote self-regulatory skills among overweight and obese adults. Furthermore, since habit-based weight loss interventions delivered via a mobile app may increase engagement to any self-regulatory skills components (Carter, Burley, Nykjaer, &

Cade, 2013), they may also be more effective at promoting these skills than paper-based interventions.

The effectiveness of 10TT could potentially also be enhanced with the addition of a tip targeting self-regulatory strategies to deal with unhealthy food. As shown in the previous chapter (Study 3), although participants' unhealthy snack and fat consumption decreased significantly over the duration of the trial, there were no differences between the 10TT and usual care conditions in how much these were reduced. Given that the 10TT leaflet primarily focuses on promoting habit formation, including additional strategies for breaking existing habits could have an additive effect. Evidence suggests that strategies such as engaging in pleasant imagery tasks (Knauper, Pillay, Lacaille, McCollam, & Kelso, 2011), developing intention implementations (Gollwitzer & Sheeran, 2006; Verplanken & Wood, 2006) and attention bias (Kakoschke et al., 2014) could potentially help people to deal with tempting food and therefore break existing unhealthy habits. There is some evidence to support the use of mobile phone apps to break habits through developing implementation intentions and also to reduce cravings for unhealthy food through the use of imagery tasks (Stawarz, Cox, & Blandford, 2015).

Delivering the 10TT weight loss intervention via a mobile app has the potential to be novel, effective, convenient, appealing, cost-effective, and wide-reaching. The addition of a self-regulatory training element to help people deal with food cravings could reduce unhealthy food intake in addition to the established effects of the 10TT on increasing healthy food intake.

7.2 Study aims and contribution to the literature

The present study aimed to develop an android app of the 10TT intervention ('Top Tips 'only' app'), and a second version that included self-regulatory strategies for dealing with tempting foods ('Top Tips 'plus' app'). It aimed to provide preliminary indications of their usage, effectiveness and acceptability. This is in line with the recommendations from the Medical Research Council (MRC) for the development of complex interventions (Craig et al., 2013), which proposes that the first phases involve the development or identification of theory, modelling processes and outcomes, followed by pilot testing of the intervention and methods. West and Michie (2016) have elaborated these recommendations to address specific issues related to digital behaviour change interventions (DBCIs). They suggest that the development of DBCIs should be flexible, ongoing and workable, and that their testing should happen in an interactive manner, involving the evaluation of their usability, acceptability, effectiveness and side effects.

Specifically, this study aimed to pilot the two versions of Top Tips app in order to obtain initial information on uptake, usage patterns and any effects on self-regulatory skills. It also aimed to provide preliminary indications of the effectiveness of the Top Tips apps at promoting weight loss, uptake of healthy behaviours and reduction in unhealthy behaviours, as well as examining the relationships between usage pattern and change in these outcomes. Qualitative data on users' experience using the apps were also obtained. It was hoped that results from this study would inform the refinement of the Top Tips app before further piloting and then evaluation in a full-scale randomized controlled trial (RCT).

7.3 Methods

The development of the Top Tips apps was completed through an interative process over a period of one year, involving 3 main phases: 1) initial development; 2) user testing and; 3) pilot testing.

7.3.1 Initial development of the Top Tips app

Both the content and format of the Top Tips apps were developed based on i) the 10TT leaflet discussed in Chapter 6 (Study 3); ii) the principles of Habit Theory; iii) empirical evidence from the field of weight loss and behavioural nutrition and; iv) the experience of the developers in designing health apps for behaviour change. It was designed for android devices by the agency White October (https://www.whiteoctober.co.uk/). The android platform was chosen because its users tend to have greater socio-economic variability compared with iOS users (A. Smith, 2013). The team of researchers and app developers met regularly during the development process, to: evaluate the progress; discuss any implementation issues, choose icons and images, and revise and approve draft versions.

Initially, White October was provided with the content material for the app, its objectives and expected functionalities. Although the Top Tips apps aimed to deliver the same content provided in the 10TT leaflet, it was necessary to update some of its content, e.g. the food labelling guide, to be in line with current nutritional recommendations. This was followed by a team workshop to explore the vision for the app and to map out the user journey and the app features. The team agreed to keep the Top Tips apps simple and initially only include the essential features (see Table 7.1), in order to keep the development process flexible and also due to budget constraints. This then led to the development of wire-frames and screenshots by the White October developers. Although the branding was kept in line with the 10TT leaflet, some necessary changes were made, to develop a coherent, well-structured and attractive app that maximised engagement with the target population.

Table 7.1 Top Tips app features

Feature	Details
Information about the Top Tips, a shopping guide, and information about habits and being overweight	Allow users to read information about the 10 target behaviours (and an extra tip on dealing with tempting food in the Top Tips 'plus' app); handy hints for each tip; shopping guide; being overweight and; how to form habits.
Weekly plan of how to adopt the tips	Allow users to enter their own plans for each tip and edit them at any time as well as seeing examples of plans.
Daily record of which tips have been achieved	Allow users to log their adherence to each tip every day.
Daily record of weight	Allow users to log their current weight in kg every day.
Weekly review of progress	Give automatic feedback on their weekly performance at adhering to the top tips.
Daily notifications reminders	Send daily notifications to increase engagement with the app.
Tracking of individual data	Provide users with individual passcodes in order to track their individual data.

To encourage habit formation, the apps required users to make context specific plans to turn each tip into a habit and edit them whenever needed. Examples of plans for each tip were provided. The app also asked users to track their weight in kg and adherence to the tips each day. In the leaflet version, users are encouraged to review their progress every week, but this was done automatically in the app versions. The apps were also set up to send daily reminders to promote engagement, but participants could turn this function off if they wanted. A total of 9 notifications were designed related to different functions of the app, e.g. "*Don't worry if you forgot to log anything last week, it's easy to add to past days – why don't you start now?".* A random notification was sent each day, this was done in the evening as it was anticipated that this would be the most likely time people would log their adherence to the target behaviours and review their plans.

The Top Tips 'plus' app included an additional tip targeting self-regulatory strategies to resist tempting food. This new tip was developed based on the current evidence for reducing unhealthy food cravings and avoiding lapses (Gollwitzer & Sheeran, 2006; Kakoschke et al., 2014; Verplanken & Wood, 2006). The tip promoted visual imagery and distraction strategies to avoid cues that elicit urges to eat unhealthy foods, which may increase the likelihood of resisting tempting food. The additional tip also provided examples of coping plans using these strategies. In line with the other tips, users were required to make their own coping plans to resist unhealthy food and monitor their progress every day, assessing whether they experienced food cravings and whether they could resist them.

7.3.2 User testing

The Top Tips ‘only’ app and the Top Tips ‘plus’ app were tested with a small convenience sample of adults who owned an android phone. The user testing aimed to assess preliminary functionality and usability of the Top Tips apps. A total of 8 (63% female) people took part in this study; of which 4 tested the Top Tips ‘only’ app and 4 tested the Top Tips ‘plus’ app. They were invited to download the latest version of the app from the Hockey app (a platform to test newly developed apps) and were given an individual passcode. Participants were instructed to enter at least one plan, log completed tips and their weight, check the content of the app for spelling errors, and provide feedback on any technical flaws.

Overall, participants reported that they liked the app, found it neat, user-friendly and attractive. Although the app worked well for most participants, the following issues were raised: 1) inability to enter decimals to their weight in kg; 2) technical flaws were reported for two specific types of android phones and; 3) difficulty understanding how to use the app due to there being no tutorial. The technical and weight recording issues were fixed by White October in the final versions of the apps. To assist participants with downloading and navigating the app, a pdf document with instructions (see Appendix 7.1) and a tutorial lasting less than 3 minutes explaining how to use the app were developed for the Top Tips ‘only’ app (https://youtu.be/i0FyNq3te4E) and for the Top Tips ‘plus’ app (https://youtu.be/n-qd9EZMUMo).

The final versions of the two Top Tips apps were released on the Google store for pilot testing. Screenshots of the tips, planning, daily tracking and automatic feedback features for the Top Tips ‘only’ app are shown in Figure 7.1, while Figure 7.2 shows these features for the Top Tips ‘plus’ app. Screenshots of the other interfaces, which were identical in both versions of the app can be found in Appendix 7.2.

Figure 7.1 Screenshots of the Top Tips 'only' app

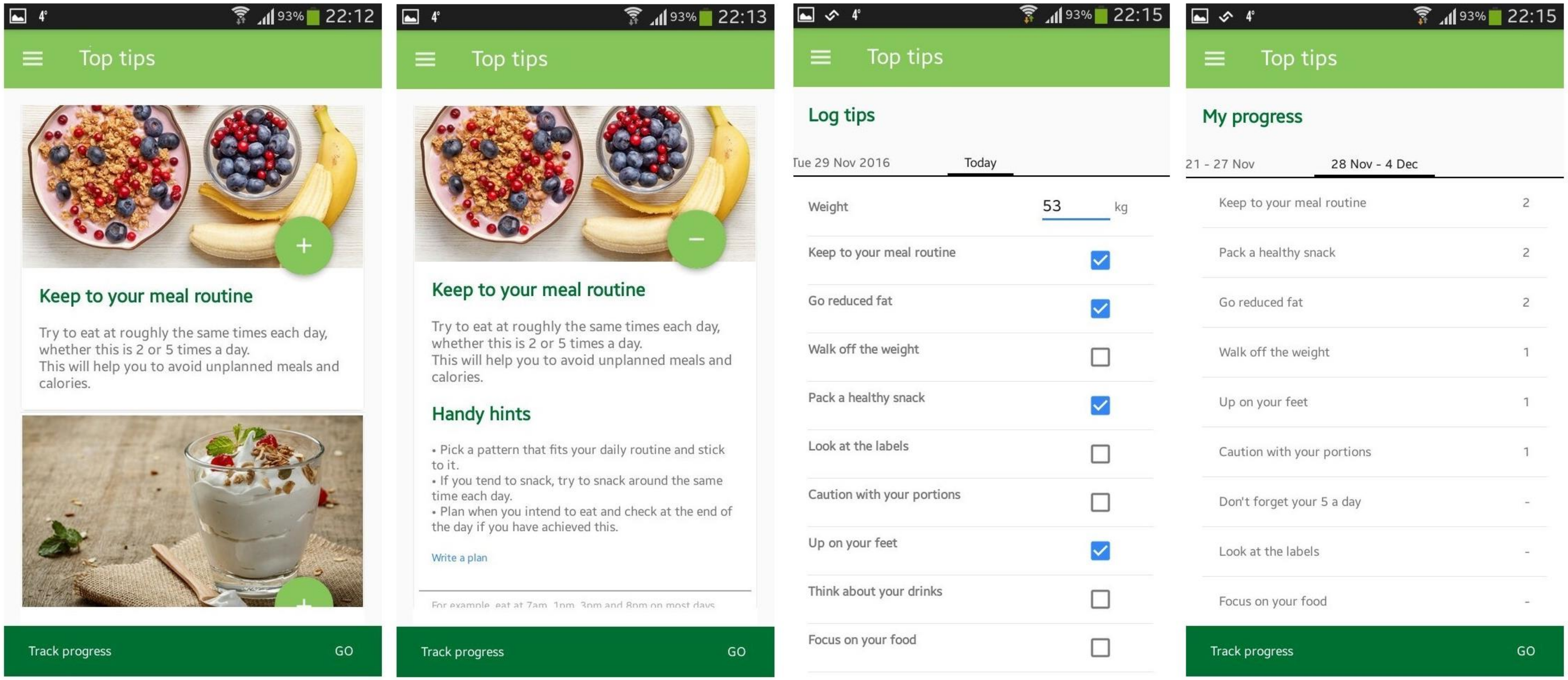
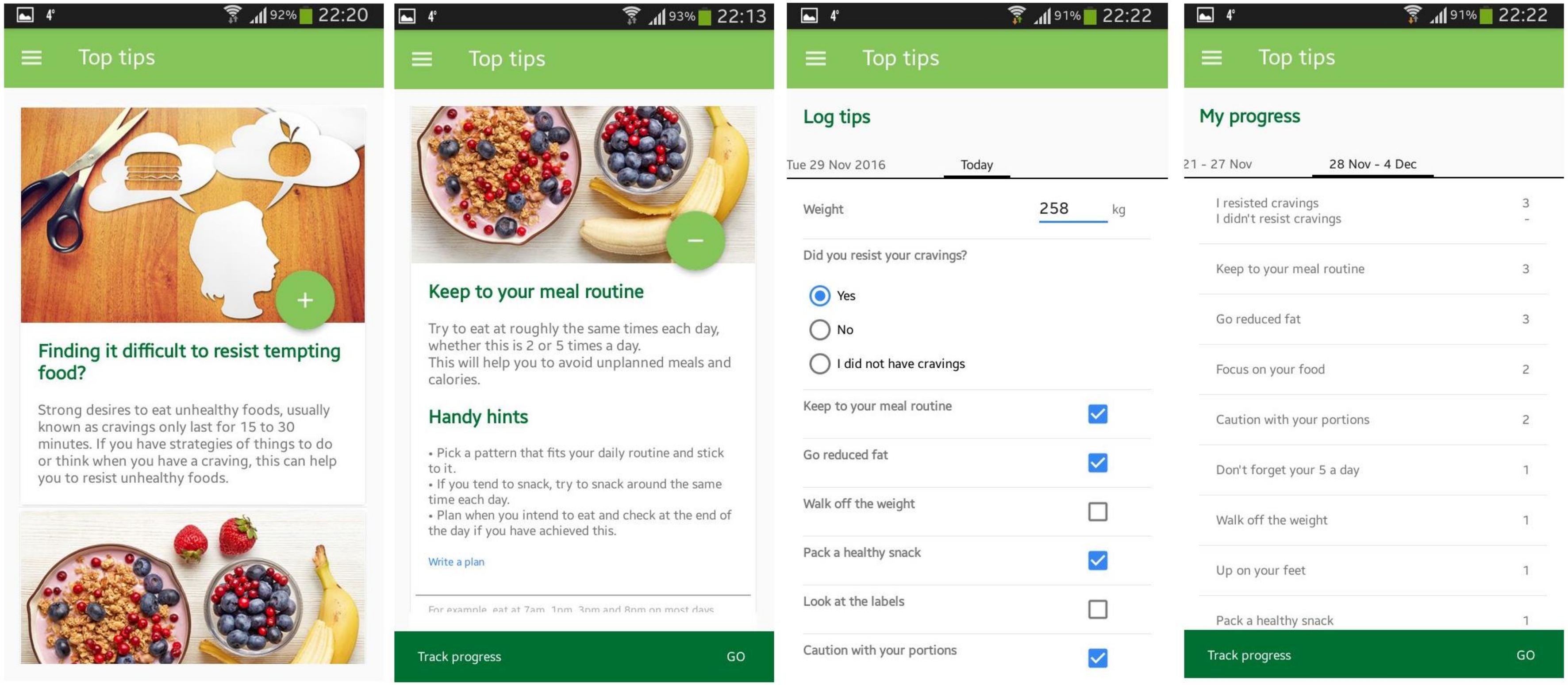


Figure 7.2 Screenshots of the Top Tips 'plus' app



7.3.3 Pilot testing

7.3.3.1 Design

This pilot was a three-arm, individually-randomised, controlled study in an online sample of overweight and obese adults, comparing: 1) Top Tips ‘only’ app; 2) Top Tips ‘plus’ app (including an additional tip on dealing with tempting foods) and 3) no intervention control group (waiting list). The active intervention period was 3 months and follow-up data were collected at the end of this period. This study was approved by the University College London ethics committee (Study ID: 5766/003; see Appendix 5.3).

7.3.3.2 Participants and Recruitment

Participants were eligible to take part in the study if they i) were adults (18 years or over) from the UK; ii) owned an android smartphone; iii) could read English fluently and; iv) were classified as overweight or obese (BMI≥25 kg/m^2). Initially only adults classified as obese (BMI≥30 kg/m^2) were allowed to participate, but due to difficulties in accessing obese participants, the recruitment was extended to additionally include adults classified as overweight (BMI≥25 kg/m^2). Participants were excluded if they i) were unable to provide informed consent, ii) were pregnant or breastfeeding, iii) were expecting to have bariatric surgery in the following 3 months or were recovering from bariatric surgery, or iv) were on a strict weight loss treatment, such as meal replacements. No upper age limit was established in line with the 10TT RCT (Beeken et al., 2012), discussed in Chapter 6.

Potential participants were invited via recruitment posters, social media, recruitment websites, and snowball sampling via personal contacts. A research website was also set up for this study to provide interested participants with additional information about the study (http://weightconcern.wixsite.com/toptips). Participants were provided with the researchers' email contact details to discuss any questions or concerns relating to the study. All contact between researchers and participants was via email and kept to a minimum to avoid biasing the results of the intervention, since face-to-face contact with a researcher may impact the effectiveness of an intervention (Kwasnicka et al., 2016). Interested participants were invited to fill out an online survey (see Appendix 7.3) using the Survey Monkey platform (https://www.surveymonkey.com.uk/), where they were screened for eligibility. Recruitment took place over 2 months, from the beginning of January to the beginning of March 2017.

7.3.3.3 Randomisation

Eligible participants who gave informed consent and completed the baseline questionnaire (see Appendix 7.4) were individually randomised to one of the three group conditions 1) Top Tips only app, 2) Top Tips plus app and 3) Waiting list. Randomisation was stratified by gender, age and BMI classification to prevent imbalances between the treatment groups that could influence the effect of the intervention. This can also prevent Type I error and improve the power of the study (Kernan, Viscoli, Makuch, Brass, & Horwitz, 1999). Randomisation was performed using Minimpy software (Saghaei, 2011).

7.3.3.4 Sample size

A rule of thumb for the sample size of pilot studies is to have at least 30 participants per randomisation group (Browne, 1995). As this study involved three experimental groups, 90 participants were required. Based on previous studies (Carter et al., 2013; Thomas & Wing, 2013), an attrition rate of 20% was anticipated, so 37 participants were required per group giving a total required sample of 111.

7.3.3.5 Procedure

After being randomised to one of the study's conditions, participants received an email with instructions about the intervention. Those randomised to the Top Tips 'only' or Top Tips 'plus' received instructions of how they should use the app; a link to watch a video showing them the steps to follow once they had downloaded the app, as well as a download link and a passcode to access the app. Participants were instructed to use the app every day for 3 months, which is the period usually required to form habits (Lally & Gardner, 2013; Lally et al., 2010). Participants randomised to the control condition received an email explaining that they had been allocated to the waiting list group and that they would receive access to the weight loss app in 3 months' time. At 3-month follow-up all participants were requested to complete the same online questionnaire applied at baseline, also using the Survey Monkey platform (https://www.surveymonkey.com.uk/). All participants had the chance to enter a draw to win one of three £20 of high street vouchers to promote completion of the post-intervention assessment. However, they were only informed about the prize draw at the end of the intervention, as we only wanted participants who were motivated to lose weight and to improve their diet to take part in the study. After the study had ended, participants in the control condition received access to the Top Tips 'only' app. Participants from the Top Tips apps conditions were also invited to answer qualitative questions at the end of the online questionnaire, exploring their experience of using the apps (Appendix 7.5).

7.3.3.6 Measures

For the present pilot study, usage pattern and users' feedback were the primary variables of interest and the impact of the intervention on self-regulatory skills, weight loss and behaviours was also explored. Demographic measures were also taken at baseline. The measures used for this study were all collected online and are described in more detail below.

Demographic characteristics

The socio-demographic questions were the same as those used in Chapters 1 and 2 (Studies 1 & 2). Participants were asked to report their gender; age; ethnicity; marital status; education and employment status. Due to the small sample size, all variables were categorised into two groups. Ethnicity was categorised as 'white' or 'other' (black; asian; mixed or other). Marital status was categorised as ‘married’ (or living as married) and ‘not married or other’ (single, separated, divorced or widowed). Education was categorised as ‘non-degree’ or ‘degree’. Employment status was categorised as ‘paid work’ and ‘unpaid work or other’ (unemployed; homemaker; voluntary work; disable or too ill to work; student or retired).

Usage metrics

Automated data from Top Tips ‘only’ and Top Tips ‘plus’ users were collected over the 3-month intervention period to assess usage patterns. This included data on the number of log-ins; pages viewed; plans made; and the total time spent on the app in minutes. Information was also collected on the number of times weight was logged and each tip was achieved. Information was also collected from the Top Tips ‘plus’ users on the number of times they resisted food cravings; number of times they did not resist; and number of times they did not have food cravings.

Self-regulatory skills

Eating self-regulatory skills were assessed at both time points using two questionnaires. The first measure used was the 5-item Self-Regulation of Eating Behaviour Questionnaire - SREBQ (Kliemann et al., 2016), developed and validated as part of this thesis (Study 1, Chapter 4). Response options ranged from 1 (never) to 5 (always). The second measure used was the 31-item Self-Regulation Questionnaire- SRQ (Carey et al., 2004), adapted for eating and weight self-regulatory skills, which was also used in the previous chapter (Study 3). Response options ranged from 1 (strongly disagree) to 4 (strongly agree). Total mean score and changes over 3 months were calculated for both scales.

Anthropometric measures

Weight and height were self-reported at baseline and 3-month follow-up using the online questionnaires. For those who did not complete the follow-up questionnaire, their last weight logged on the app was used. Changes in weight in kg over 3 months were calculated. Body Mass Index (BMI) was also calculated by dividing weight (kg) by height (m) squared. BMI was then categorised into overweight (25-29.9 kg/m^2) or obese (30 kg/m^2 or over).

Behaviours

Frequency of the target behaviours (dietary, physical activity and weighing behaviours) was assessed using the same questions used in the previous chapter (Study 3). As previously described, the intervention targeted 10 eating and activity behaviours plus self-weighing. For some of these behaviours more than one frequency question was generated to better assess adherence to the behaviour. For example, for the ‘look at labels’ behaviour, two questions on the frequency of how often people look at labels when preparing food and when buying food were generated. A total of 16 questions were used to assess the frequency of carrying out each of the target behaviours over the previous two weeks, on a 5-point Likert scale, from ‘none of the time’ to ‘all of the time. The overall mean score for the 16 behaviours was calculated as well as the mean change from baseline to 3-month follow-up.

Also, similar to the previous chapter (Study 3), dietary intake was assessed in more detail using validated food frequency questionnaires. Fat intake was assessed using the dietary fat scale from the validated Dietary Instrument for Nutrition Education (DINE), a brief food frequency questionnaire that has good agreement with food diaries (Roe et al., 1994). For the present study, the scale was adapted to broaden the range of ethnically diverse foods and the main components of the UK diet. Fruit and vegetable intake (F&V) were assessed using the same valid 2-item food frequency questions used in the Chapter 6 (Cappuccio et al., 2003). Respondents reported their intake on a 7-point response scale that ranged from 1 (less than 1 portion per week) to 7 (three or more portions per day). Similarly, two food frequency questions assessed sweet snack intake (SS), such as chocolates, sweets biscuits, cakes, buns, pastries and ice-cream. Four frequency questions assessed the consumption of sugary drinks intake (SD), such as non-diet fizzy drinks, sugar-containing squashes, milkshakes and hot chocolate. The response options ranged from 1 (never/ rarely) to 7 (3 or more times a day). Following Mcgowan et al (2012), answers were recoded to represent daily intake, for example, ‘2-3 times a week’ was coded as 0.36. The mean score for the frequency F&V, SS and SD were calculated as well as the mean change from baseline to 3-month follow-up.

Users’ feedback

To assess acceptability of the Top Tips apps, eight open questions relating to users’ experience of using the apps were included in the online follow-up questionnaire. This included their overall views towards the app; if there was anything that they disliked or found hard to use; if there was anything they liked or found easy to use; if there was anything that they were expecting to see but did not; how the app could be improved and if they had any other comments they would like to make. It was optional to answer these questions.

7.3.3.7 Statistical analyses

All analyses were conducted on an intention-to-treat basis, with participants analysed based on assigned randomisation group (Hollis & Campbell, 1999). Descriptive analyses were used to characterize the sample by study arm, including information on socio-demographics, BMI and eating self-regulatory skills. Baseline differences between those who downloaded and did not download the app and between completers and non-completers for eating self-regulatory skills at 3-month follow-up were tested using Chi-square tests for categorical variables and t-tests or Mann-Whitney tests for continuous variables.

Assumptions of normality were assessed by visual inspection, using histograms and P-P plots, and also by statistical parameters such as median, mean, skewness and kurtosis. For small sample sizes (~50 to 300), a cut-off point of z-scored <1.96 for either skewness and kurtosis is recommended (as cited in Kim, 2013). The formal normality tests, Kolmogorov-Smirnov test and Shapiro-Wilk test, were also undertaken, which indicates that data are not normally distributed when results are non-significant.

Descriptive analyses were also used to show the usage pattern of the Top Tips apps. Since both apps were identical apart from the tip on dealing with tempting food added only to the Top Tips plus, an overall usage pattern was also performed. Mean, standard deviation, median and minimum and maximum were reported for each usage metric.

Exploratory descriptive analyses were performed to obtain an early indication of the effect of the Top Tips apps on eating self-regulatory skills, weight and behaviours, including dietary intake. Initially a completer analysis was performed using complete data at baseline and follow-up for each outcome. Participants with more than 20% of missing data at baseline for the self-regulation and target behaviours questionnaires and with any missing data for dietary intake questions were excluded from the analyses. When there was up to 20% missing data for the self-regulation and target behaviours questionnaires, the individual median score was imputed.

Within-group changes from baseline to 3 months were described for each outcome and the Cohen’s effect size calculated. Initially completers’ analyses were performed including only participants with data at both time points for each outcome. Secondly, a sensitivity analysis using the last observation carried forward approach was performed to investigate the potential effect of missing responses on the effect sizes. This is a conservative approach that inputs missing data from baseline characteristics.

Descriptive analyses was also used to assess the relationships between overall app usage and changes in eating self-regulatory skills, weight and target behaviours over 3 months. For this analysis, the level of change in self-regulatory skills, weight and target behaviours were categorised into two groups using ranked percentiles: i) percentile <75 represented medium to small changes and ii) percentile ≥75 represented large changes.

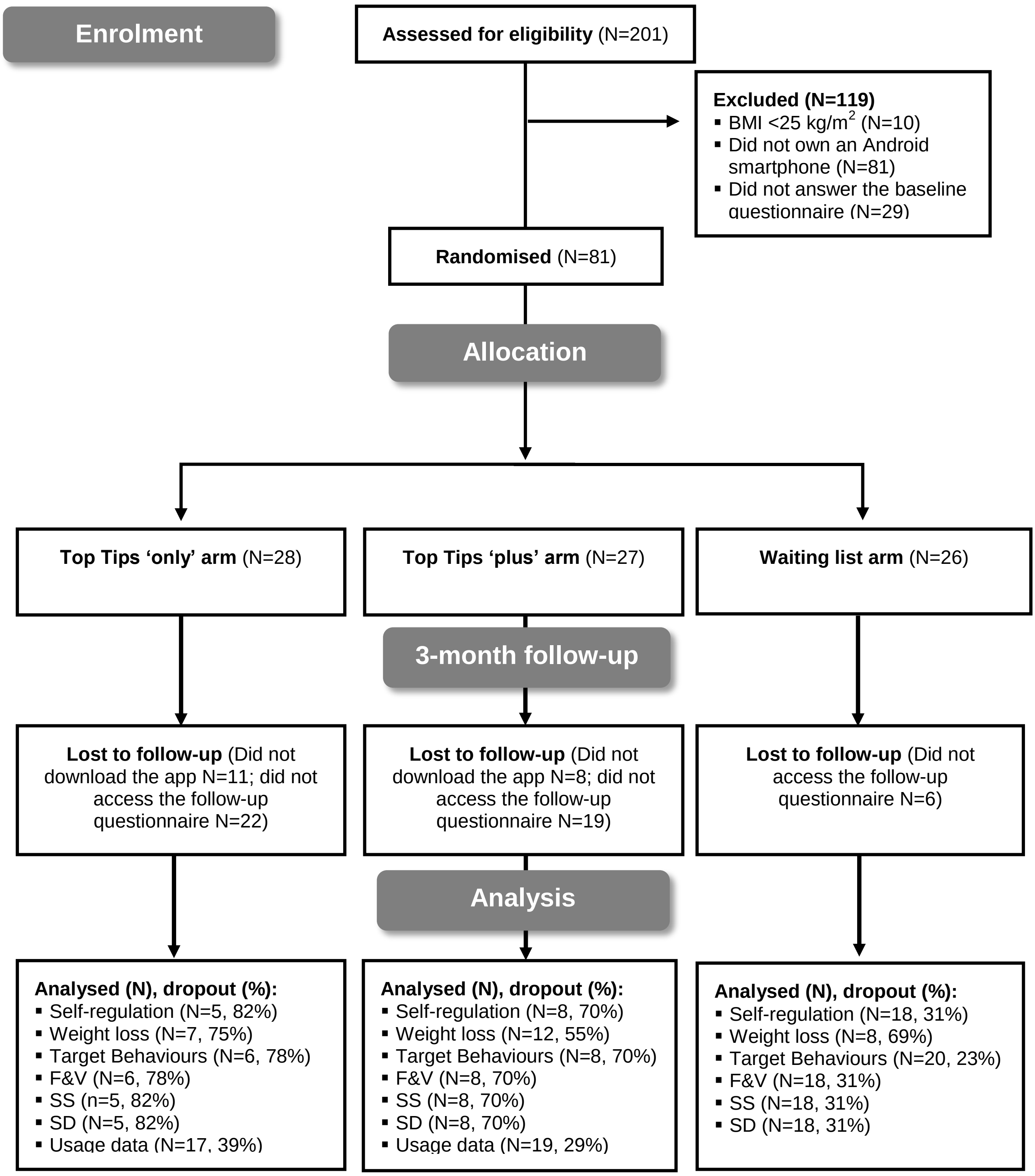
Users’ feedback on their experience using the app was analysed using thematic analysis, a widely used analytic method for qualitative data in psychology research (Braun & Clarke, 2006). This method identifies and report patterns (themes) within data. All quantitative analyses were undertaken using SPSS version 24.0 (SPSS Inc) and statistical significance was defined as a value of $p<0.05$.

7.4 Results

7.4.1 Participants flow and characteristics

A total of 201 adults were interested in the intervention and were assessed for eligibility. Of these, 120 were excluded because they had a BMI<25.0 kg/m^2 (N=10), did not own an android smartphone (N=81) or did not complete the baseline questionnaire (N=29). A total of 81 participants were eligible to take part in the study; 28 were randomised to the Top Tips only app; 27 to the Top Tips plus app and 26 to the waiting list group. Figure 7.3 displays the flow diagram of study participation over the 3 month study period.

Figure 7.3 Flow diagram of participation during the 3-month study period



Note= Self-regulation refers to data for the Self-Regulation of Eating Behaviour Questionnaire (SREBQ). Target Behaviours refers to data for the frequency of the 16 target behaviours. F&V refers to data for Fruit and vegetable intake in servings per day. SS refers to data for daily occasions of sweet snacks intake. SD refers to data for daily occasions of sugary drinks intake. Usage data refers to the automated data obtained from the Top Tips apps. Feedback refers to qualitative data obtained on users' experience using the app.

Table 7.2 shows the baseline characteristics of the participants, which appeared similar across the three study arms. The majority of the participants were female (~90%), and white (~84%). Approximately two thirds had a degree (~74%) and half were married (~54%) and were in paid work (~59%). Overall mean age was 42.4 (sd=13.4) and BMI was 34.3 kg/m^2 (sd=7.0).

Table 7.2 Baseline characteristics of the condition groups

Characteristics	Top Tips only (n=28)	Top Tips Plus (n=27)	Waiting list (n=26)
Gender			
Female, % (n)	85.7 (24)	92.9 (25)	92.3 (24)
Age (in years)			
Mean (sd)	43.6 (13.1)	44.0 (14.0)	40.6 (13.5)
Ethnic group			
White, % (n)	82.1 (23)	85.2 (23)	84.6 (22)
Other[a], % (n)	17.9 (5)	14.8 (4)	15.4 (4)
Marital status			
Married[b], % (n)	53.6 (15)	55.6 (15)	53.9 (14)
Not Married or other[c], % (n)	46.4 (13)	44.4 (12)	46.1 (12)
Education			
Non-degree[d], % (n)	21.4 (6)	29.6 (8)	26.9 (7)
Degree[e], % (n)	78.6 (22)	70.4 (19)	69.2 (18)
Missing, % (n)			1 (3.8)
Employment situation			
Paid work[f], % (n)	71.4 (20)	55.6 (15)	50.0 (13)
Unpaid work or other[g], % (n)	28.6 (8)	44.4 (12)	46.1 (12)
Missing, % (n)	-	-	3.9 (1)
Weight status			
Overweight[h], % (n)	28.6 (8)	25.9(7)	26.9 (7)
Obese[i], % (n)	71.4 (20)	74.1 (20)	73.1 (19)
Body Mass Index (BMI)			
Mean (sd)	33.7 (6.7)	35.0 (7.6)	34.0 (7.0)
Eating Self-Regulatory skills[j]			
Mean (sd)	2.81 (.57)	2.87 (.69)	2.85 (.51)

Note= [a]Black, Asian, Mixed or other. [b]Married or living as married. [c]Single, separated, divorced or widowed. [d]Primary/secondary school or O level/ GCSEs/ A levels or technical/ trade certificate/ diploma. [e]Degree or Post-graduate degree. [f]Employed full-time/ employed part-time/ self-employed [g]Unemployed/ full-time homemaker/ unpaid or voluntary work/ disable or too ill to work/ student/ retired. [h]BMI from 25.0 to 29.9 Kg/m^2. [i]BMI 30.0 Kg/m^2 or over. [j]Eating self-regulatory skills assessed using the Self-Regulation of Eating Behaviour Questionnaires (SREBQ).

The Top Tips app was downloaded by 60% (N=17) of the participants randomised to the Top Tips 'only' condition and by 70.4% (N=19) of those randomised to the Top Tips 'plus' condition. As shown in Table 7.3, those who did not download the app were not significantly different at baseline for any of the socio-demographic variables from those who downloaded the app.

Table 7.3 Baseline characteristics by those who downloaded and did not download the Top Tips apps

Characteristics	Downloaded (N=36)	Did not download (N=19)	Statistics
Gender			
Female, % (N)	91.7 (33)	84.2 (16)	Fisher's exact test=.405
Age (in years)			
Mean (sd)	45.5 (12.9)	39.6 (13.9)	t(53)=1.539, *p*=.130
Ethnic group			
White, % (N)	86.1 (31)	78.9 (15)	Fisher's exact test=.703
Other[a], % (N)	13.9 (5)	21.1 (4)	
Marital status			
Married[b], % (N)	63.9 (23)	36.8 (7)	$X^2(1)=3.669$, *p*=.05
Not Married or other[c], % (N)	36.1 (13)	63.2 (12)	
Education			
Non-degree[d], % (N)	25.0 (9)	26.3 (5)	Fisher's exact test=.580
Degree[e], % (N)	75.0 (27)	73.7 (14)	
Employment situation			
Paid work[f], % (N)	69.4 (25)	52.6 (10)	$X^2(1)=1.519$, *p*=.218
Unpaid work or other[g], % (N)	30.6 (11)	47.4 (9)	
Weight status			
Overweight[h], % (N)	33.3 (12)	15.8 (3)	Fisher's exact test=.213
Obese[i], % (N)	66.7 (24)	84.2 (16)	
Body Mass Index (BMI)			
Mean (sd)	34.3 (7.6)	34.5 (6.5)	Mann-Whitney test=.763
Eating Self-Regulatory skills[j]			
Mean (sd)	2.8 (.53)	2.9 (.80)	t(54)=-.567, *p*=.573

Note= [a]Black, Asian, Mixed or other. [b]Married or living as married. [c]Single, separated, divorced or widowed. [d]Primary/secondary school or O level/ GCSEs/ A levels or technical/ trade certificate/ diploma. [e]Degree or Post-graduate degree. [f]Employed full-time/ employed part-time/ self-employed [g]Unemployed/ full-time homemaker/ unpaid or voluntary work/ disable or too ill to work/ student/ retired. [h]BMI from 25.0 to 29.9 Kg/m^2. [i]BMI 30.0 Kg/m^2 or over. [j]Eating self-regulatory skills assessed using the Self-Regulation of Eating Behaviour Questionnaire (SREBQ).

A total of 31 participants provided data on eating self-regulatory skills (assessed using the SREBQ) at both baseline and 3-month follow-up. Of these, 5 were in the Top Tips ‘only’; 8 in the Top Tips ‘plus’ and 18 in the waiting list condition. Table 7.4 shows that non-completers were not significantly different at baseline from those who provided data at both time points.

Table 7.4 Baseline characteristics by completers and non-completers for eating self-regulatory skills at 3-month follow-up

Characteristics	Eating self-regulatory skills		Statistics
	Completers (N=31)	Non-completers (N=50)	
Gender			
Female, % (N)	90.3 (28)	90.0 (45)	Fisher’s exact test=.639
Age (in years)			
Mean (sd)	42.2 (13.0)	42.7 (13.7)	t(79)=-.162, *p*=.871
Ethnic group			
White, % (N)	83.9 (29)	84.0 (42)	Fisher’s exact test=.610
Other[a], % (N)	16.1 (5)	16.0 (8)	
Marital status			
Married[b], % (N)	54.8 (17)	54.0 (27)	$\chi^2(1)=.005$, $p=.941$
Not Married or other[c], % (N)	45.2 (14)	46.0 (23)	
Education			
Non-degree[d], % (N)	22.6 (7)	28.6 (14)	$\chi^2(1)=.352$, $p=.611$
Degree[e], % (N)	77.4 (24)	71.4 (35)	
Employment situation			
Paid work[f], % (N)	71.0 (22)	53.1 (26)	$\chi^2(1)=2.537$, $p=.111$
Unpaid work or other[g], % (N)	29.0 (9)	46.9 (23)	
Weight status			
Overweight[h], % (N)	22.6 (7)	30.0 (15)	$\chi^2(1)=.532$, $p=.466$
Obese[i], % (N)	77.4 (24)	70.0 (35)	
Body Mass Index (BMI)			
Mean (sd)	34.2 (6.4)	34.3 (7.6)	Mann-Whitney test=.613
Eating Self-Regulatory skills[j]			
Mean (sd)	2.9 (.66)	2.8 (.54)	t(79)=.706, *p*=.482

Note= [a]Black, Asian, Mixed or other. [b]Married or living as married. [c]Single, separated, divorced or widowed. [d]Primary/secondary school or O level/ GCSEs/ A levels or technical/ trade certificate/ diploma. [e]Degree or Post-graduate degree. [f]Employed full-time/ employed part-time/ self-employed [g]Unemployed/ full-time homemaker/ unpaid or voluntary work/ disable or too ill to work/ student/ retired. [h]BMI from 25.0 to 29.9 Kg/m^2. [i]BMI 30.0 Kg/m^2 or over. [j]Eating self-regulatory skills assessed using the Self-Regulation of Eating Behaviour Questionnaire (SREBQ).

7.4.2 Usage pattern

Usage pattern for each Top Tip app and overall is presented in Table 7.5. Although there was a great variability within participants, on average participants viewed a mean of 43.4 (sd=66.9) screens, during a mean of 24.5 (sd=44.07) log-in and used the app for 124.2 (sd=240.2) minutes over the 3-month intervention. Plans were made on average 4.6 (sd=3.9) times; weight was logged around 8.3 (sd=15.9) times and; tips were achieved on average 10.1 (sd=21.2) times over the course of the intervention. Participants randomised to the Top Tips ‘only’ condition seemed to have used the app twice as much as those randomised to the Top Tips ‘plus’ condition.

Table 7.5 Usage pattern per app and overall

Usage pattern	Top Tips only (n=17)	Top Tips plus (n=20)	Overall (n=37)	
	M (sd)	M (sd)	M (sd)	Min-Max^
Number of screens viewed	56.6 (94.9)	32.2 (24.9)	43.4 (66.9)	2-283
Number of log-ins	33.8 (63.1)	16.5 (13.5)	24.5 (44.07)	1-253
Cumulative minutes using the app	162.1 (296.5)	92.1 (181.4)	124.2 (240.2)	.01-1200.8
Number of plans made	4.8 (3.9)	4.4 (3.9)	4.65 (3.9)	0-11
Number of times weight was logged	9.9 (20.8)	6.8 (10.3)	8.3 (15.9)	0-74
Number of times tips were achieved	14.0 (29.0)	6.7 (9.9)	10.1 (21.2)	0-102
Number of times each tip was achieved				
1. Keep to your meal routine	.06 (.24)	.35 (.81)	.22 (.63)	0-3
2. Go reduced fat	.18 (.52)	.25 (.55)	.22(.53)	0-2
3. Walk off the weight	.00(.00)	.00(.00)	.00 (.00)	0-0
4. Pack a healthy snack	.12 (.48)	.15(.36)	.14 (.42)	0-2
5. Look at the labels	.18 (.53)	.25(.71)	.22 (.63)	0-3
6. Caution with your portions	12.4 (28.4)	4.4 (6.9)	8.1 (20.0)	0-100
7. Up on your feet	.06 (.24)	.10(.31)	.08 (.27)	0-1
8. Think about your drinks	.06(.24)	.10(.31)	.08(.27)	0-1
9. Focus on your food	.29(.47)	.35(.59)	.32(.53)	0-2
10. Don’t forget your 5-a-day	.65 (1.0)	.85(1.75)	.76(1.46)	0-7
Extra: Cravings were resisted[a]	-	4.6(6.8)	4.6(6.8)	0-25
Extra: Cravings were not resisted[b]	-	3.2(4.6)	3.2(4.6)	0-16

Note= [a]Number of times people resisted their food cravings. [b]Number of times participants did not resist their food cravings. M:mean. sd:standard deviation. ^Min-Max: minimum and maximum observations.

The tip most frequently achieved was ‘Caution with portions’ (M=8.1, sd=20.0), followed by ‘don’t forget your 5 a day’ (M= 0.76, sd=1.46) and ‘Focus on your food’ (M=0.32, sd=0.53). The tip least achieved was ‘Walk off the weight’, which was not achieved by any participant during the entire intervention. This pattern was found in both apps. Regarding the tip on how to resist tempting food within the Top Tips plus app, participants logged success (M=4.6, sd=6.8) more times than failure (M=3.2, sd=4.6) for their attempts to resist tempting food.

7.4.3 Post-intervention effect on eating self-regulatory skills

As shown in Table 7.6, eating self-regulatory skills, when assessed using the SREBQ, increased the most in the Top Tips only (M=0.59, sd=1.0), followed by the Top Tips plus (M=0.15, sd=0.42) and no changes were found for the waiting list condition (M=-0.02, sd=0.29). These changes represented a medium-sized effect for the Top Tips only and small-sized effect for the Top Tips plus condition, which were in line with the effect sizes found in the sensitivity analysis. Similar results were found when eating self-regulatory skills were assessed using the adapted SRQ, although the effect sizes were slightly higher for this questionnaire in both the completers and sensitivity analysis.

Table 7.6 Preliminary indication of the effect of the Top Tips apps on eating self-regulatory skills

Outcome	Top Tips only					Top Tips plus					Waiting list				
		Baseline	Follow-up	Changes			Baseline	Follow-up	Changes			Baseline	Follow-up	Changes	
	N	M (sd)	M (sd)	M (sd)	d[¥]	N	M (sd)	M (sd)	M (sd)	d[¥]	N	M (sd)	M (sd)	M (sd)	d[¥]
Completers															
SREBQ[1]	5	2.7(.64)	3.3(1.1)	.59(1.0)	.53	8	3.0(.95)	3.2(.72)	.15(.42)	.35	18	2.8(.53)	2.8(.41)	-.02(.29)	.06
SRQ[2]	5	2.2(.64)	2.5(.82)	.32(.38)	.84	8	2.5(.48)	2.7(.60)	.27(.48)	.57	18	2.4(.37)	2.3(.35)	-.08(.22)	.39
Sensitivity analysis															
SREBQ[1]	28	2.8(.57)	2.9(.71)	.10(.47)	.48	27	2.8(.62)	2.9(.62)	.04(.23)	.19	26	2.8(.51)	2.8(.43)	-.01(.24)	.04
SRQ[2]	27	2.2(.46)	2.2(.52)	.05(.19)	.30	27	2.3(.45)	2.4(.53)	.08(.28)	.30	26	2.4(.36)	2.3(.36)	-.06(.18)	.32

Note= [1]Eating self-regulatory skills assessed using the Self-Regulation of Eating Behaviour Questionnaire, scores ranged from 1 (never) to 5 (always). [2]Eating self-regulatory skills assessed using the Self-Regulation Questionnaire adapted for weight and diet, scores ranged from 1 (strongly disagree) to 4 (strongly agree). Sensitivity analysis used the Last observation carried forward approach. M= mean. sd=Standard deviation. [¥]Cohen's d effect size.

7.4.4 Post-intervention effect on weight and behaviours

Table 7.7 presents the results for the effect of the Top Tips apps on weight loss and target behaviors, including dietary intake. The results suggest that weight loss was greater in the Top Tips only (M=-4.5, sd=5.2), followed by the Top Tips plus (M=-1.9, sd=3.9) and no weight loss was found in the waiting list condition (M=-0.01, sd=0.51). This represented a large-sized effect for the Top Tips only and a medium-sized effect for the Top Tips plus, but according to the sensitivity analysis the effect on weight loss was small for both app conditions.

Similarly, the Top Tips only promoted a greater increase in the adherence to the target behaviours (M=0.59, sd=0.49) than the Top Tips plus (M=0.29, sd=0.29), while no changes were observed for the waiting list (M=0.08, sd=0.38) condition. These changes represented a large-sized effect for both app conditions. However, the sensitivity analysis suggested that the effect of both apps on adherence to the target behaviours represented a medium-sized effect.

Regarding the effect on dietary intake, the Top Tips plus showed the greatest increase in F&V intake (M=0.42, sd=0.97), representing a medium-sized effect, while both Top Tips only (M=0.26, sd=0.74) and the waiting list (M=0.22, sd=1.0) showed a small effect size. The Top Tips plus condition also showed the greatest decrease in SS (M=-0.29, sd=0.66) and SD (M=-0.13, sd=0.33) intake, representing a medium-sized effect. The Top Tips only showed smaller changes in SS (M=-0.04, sd=0.10) and SD (M=-0.07, sd=0.09) than the Top Tips plus, but the magnitude of the effect was also medium, while it represented a small-sized effect for both outcomes in the waiting list condition (M_{ss}=-0.18 sd=0.52; M_{SD}=-0.03, sd=0.10). With respect to fat intake, the Top Tips only showed the greatest changes (M=-0.42, sd=8.01), representing a medium-sized effect, whereas the Top Tips plus (M=-0.12, sd=12.8) and the waiting list (M=-3.1, sd=8.1) showed a small effect. Sensitivity analyses suggested a small effect size for all the results.

Table 7.7 Preliminary indication of the effect of the Top Tips apps on weight loss and behaviours

Outcome		Top Tips only					Top Tips plus					Waiting list			
	N	Baseline M (sd)	Follow-up M (sd)	Changes M (sd)	d¥	N	Baseline M (sd)	Follow-up M (sd)	Changes M (sd)	d¥	N	Baseline M (sd)	Follow-up M (sd)	Changes M (sd)	d¥
Completers															
Weight in kg	7	97.5(14.9)	93.0(11.6)	-4.5(5.2)	.8	11	88.7(18.1)	86.8(19.3)	-1.9(3.9)	.5	8	88.5(14.6)	88.5(17.3)	-.01(5.1)	.002
Target Behaviours[1]	6	3.1(.42)	3.7(.60)	.59(.49)	1.1	8	3.6(.48)	3.8(.47)	.29(.29)	1.0	20	3.1(.44)	3.2(.46)	.08(.38)	.22
F&V intake[2]	5	1.8(.85)	2.1(1.0)	.26(.74)	.35	8	1.7(1.1)	2.2(1.0)	.42(.97)	.43	18	1.6(.75)	1.8(.85)	.22(1.0)	.21
SS intake[3]	5	.20(.18)	.16(.22)	-.04(.10)	.45	8	.65(.55)	.36(.33)	-.29(.66)	.43	18	.47(.50)	.39(.22)	-.18(.52)	.35
SD intake[4]	5	.11(.05)	.04(.04)	-.07(.09)	.78	8	.17(.40)	.03(.07)	-.13(.33)	.40	18	.15(.16)	.12(.16)	-.03(.10)	.25
Fat intake[5]	5	28.2(7.0)	24.0(6.4)	-4.2(8.01)	.52	8	37.6(15.1)	37.5(15.7)	-.12(12.8)	.01	18	38.0 (11.4)	34.8(10.7)	-3.1(8.1)	.04
Sensitivity analysis															
Weight in kg	28	93.5 (15.4)	92.4(14.6)	-1.1(3.1)	.35	27	93.1(19.5)	92.3(20.2)	-.78(2.66)	.29	26	93.6(23.4)	93.6(23.9)	-.004(2.7)	.001
Target Behaviours[1]	28	3.0(.35)	3.1(.50)	.12(.32)	.38	27	3.2(.51)	3.3(.58)	.09(.20)	.43	26	3.0(.45)	3.1(.48)	.06(.33)	.19
F&V intake[2]	28	1.77(.87)	1.82(.90)	.04(.30)	.15	27	1.52(1.1)	1.64(1.1)	.12(.54)	.22	26	1.50(.71)	1.65(.81)	.15(.85)	.18
SS intake[3]	28	.63(.73)	.62(.73)	-.01(.04)	.19	27	.65(.76)	.56(.73)	-.08(.37)	.23	26	.47(.45)	.34(.21)	-.13(.43)	.29
SD intake[4]	28	.17(.22)	.16(.22)	-.01(.04)	.28	27	.16(.26)	.12(.16)	-.04(.18)	.21	26	.17(.16)	.15(.17)	-.02(.08)	.21
Fat intake[5]	28	35.4(12.2)	34.7(12.7)	-.75(3.5)	.21	27	36.8(14.1)	36.7(14.3)	-.03(6.6)	.005	26	36.0(11.1)	33.8(10.3)	-2.2(6.8)	.32

Note= [1]Overall mean score for the frequency of the 16 target behaviours, scores ranged from 1 (none of the time) to 5 (all of the time). [2]Fruit and vegetable intake in servings per day. [3]Daily occasions of sweet snacks intake. [4]Daily occasions of sugary drinks intake. [5]Score for the DINE questionnaire - Cut offs: <30 low fat; 30-40 medium fat; >40 high fat. Sensitivity analysis used the Last observation carried forward approach. M= mean. sd=Standard deviation. [¥]Cohen's d effect size

7.4.5 Relationships between app usage and changes in eating self-regulatory skills, weight and target behaviours

Table 7.8 shows the relationships between the Top Tips apps usage and changes in self-regulatory skills, weight and adherence to target behaviours. The results suggest that participants with the greatest changes for these outcomes, on average, viewed pages 2 to 3 times more; had 2 to 3 times more log-ins, logged their weight 2 to 3 times more and achieved the tips more than those who showed smaller changes in these outcomes. Moreover, participants with the greatest changes in eating self-regulatory skills, weight and adherence to target behaviours made on average 1, 2 and 3 plans less than those with smaller changes, respectively. App usage in minutes was also higher among those with greater improvements for eating self-regulatory skills (~500% higher) and target behavior (~140% higher), than those who made smaller changes. In contrast, those who lost more weight used the apps about 15% less in minutes than those who lost less weight over the course of the intervention.

Table 7.8 App usage per level of changes in self-regulatory skills, weight and target behaviours over 3 months (Data from both Top Tips apps)

Changes over 3 months	All app participants[∞]		Number of screens viewed		Number of log-ins		Cumulative minutes using the app		Number of plans made		Times weight was logged		Times tips were achieved	
	N	M (sd)	M (sd)	MED	M (sd)	MED	M (sd)	MED	M (sd)	MED	M (sd)	MED	M (sd)	MED
Self-regulation[1]														
Per percentile[Δ]														
< 75	8	-.06(.58)	41(26)	37	22(14)	18	48.6(57.8)	15.9	6(4)	7	7(4)	6	7.7(4.3)	5
≥ 75	5	.92(.58)	84(113)	41	38(45)	22	241.6(339.1)	64.6	5(5)	8	24(32)	6	23.2(30.6)	9
Weight[2]														
Per percentile[Δ]														
< 75	6	1.13(2.09)	62(63)	6	26(21)	21	212.9(315.7)	50.3	7(4)	8	9(9)	6	10.3(11.2)	7
≥ 75	12	-4.97(4.05)	85(101)	12	53(73)	32	184.8(350.6)	60.6	5(4)	6	21(24)	10	25.5(33.2)	10
Target behaviours[3]														
Per percentile[Δ]														
< 75	7	.12(.26)	38(20)	39	18(11)	19	175.8(310.6)	35.9	7(4)	7	7(4)	6	7.5(5.13)	7
≥ 75	7	.73(.26)	109(122)	72	69(89)	44	242.0(438.3)	64.6	4(5)	2	25(28)	10	32.4(39.9)	10

Note= [1]Changes in Eating self-regulatory skills assessed using the Self-Regulation of Eating Behaviour Questionnaire. [2]Changes in weight in kg. [3]Changes in the overall mean score for the frequency of the 16 target behaviours. [Δ]Changes to the outcome over 3 months categorised according to the percentile, that is - <75= medium to low changes and ≥ 75= greater changes. [∞]Data from Top Tips only's and Top Tips Plus' participants. M= mean. sd= Standard deviation. MED= Median. 3 months was equivalent to 15 weeks.

7.4.6 Acceptability feedback

A total of 8 participants gave feedback of their experience using the Top Tips apps. Of these, 75% were female (N=7). Two participants complained about technical issues. One of them said that they had an issue downloading the app and therefore was unable to follow the intervention and the other one was unable to access the daily tips.

Participants' overall views toward the app involved positive and negative comments. Some participants mentioned that they did not find the app useful, and found it unoriginal and boring. Others said the app was well designed and helped them to track their diet plan.

"It is very well designed. It helps you to keep track of your weight loss goals."

[Male, 30 years old]

"I didn't find it particularly helpful."

[Female, 43 years old]

"Helped me focus on my diet plan."

[Female, 57 years old]

"Boring, unoriginal and old hat."

[Female, 58 years old]

Participants also commented on what they liked and found easy to use. The way the tick boxes were designed to track their adherence to the target behaviours was considered effective and easy to use. Some participants also mentioned that they liked the daily reminders and the possibility of setting their own plans.

"[I liked the] daily weight reminder"

[Female, 57 years old]

"The way you have to tick boxes. Easily and effective. It helps you to build new eating habits."

[Male, 30 years old]

In contrast, some participants said they disliked the reminder, as they found it annoying. The lack of interactivity was also mentioned as a negative aspect of the Top Tips app and also the fact that they could not tailor the app more to their personal needs.

"Lack of any interactivity."

[Female, 50 years old]

"Absence of feedback support."

[Female, 58 years old]

"*Couldn't delete the goals I didn't like*."

[Female, 43 years old]

With respect to users' expectations, some participants said that the app was just not what they expected. Some were expecting the app to include a food diary and allow them to tailor the goals to their needs more. Some were also expecting that the app would involve more complex information related to weight loss.

"Just wasn't what I expected."

[Female, 56 years old]

"New ideas motivating information on metabolism and food and exercise. Your app had the standard I would expect from a gcse student."

[Female, 58 years old]

"Ability to tailor goals more."

[Female, 43 years old]

Finally, participants made some suggestions for improving the Top Tips app. Some participants suggested the inclusion of recipes and the use of different strategies to remind people about the tips apart from the daily notifications, such as emails. They also suggested the inclusion of food diaries to track their dietary intake.

"Reminders should come up at different times - and also try different strategies (notifications, e-mail, etc.). It could [also] include healthy recipes to help people cook healthy food at home."

[Male, 30 years old]

"Something more like my fitness pal."

[Female, 50 years old]

7.5 Discussion

The study suggested that the Top Tips habit-based app could potentially be a useful intervention for promoting eating self-regulatory skills, weight loss and healthy behaviours among overweight and obese adults. The usage patterns indicated those who engaged more with the app also showed greater changes in self-regulatory skills, weight and adherence to target behaviours. Although there are hundreds of commercially available smartphone apps designed to help people lose weight or form habits, most of these are neither theory nor evidence-based (Thomas & Bond, 2014). Therefore, this is one of the first studies to provide some indications of the usage and effect of a weight loss app intervention based on habit theory.

Although the study did not reach the target sample size (N=111), there was significant interest in the study: over two months 201 people signed up for the study. Of these, 81 overweight and obese adults were excluded because they did not have an android phone. Among those randomised to the app conditions, about a third did not download the app, suggesting a reduction in interest before even beginning the intervention. The responses for the follow-up online questionnaire were also very low for the app conditions (~25%). In contrast, the follow-up response for the waiting list was high (77%), possibly due to the fact that completing the follow-up questionnaire was a condition for subsequent access to the Top Tips app. Future studies should improve the instruction materials and test other strategies to reduce the drop-out for the intervention conditions. The inclusion of face-to-face or telephone support before and after technology-based interventions may increase retention and engagement as well as weight loss (Schippers et al., 2017). Additionally, making the app available for iOS (Apple's operation system) could increase the reach of the intervention and also improve retention (Localytics, 2012). Dual phone-computer access could also help increase retention, since it is valued by users (Tang, Abraham, Stamp, &

Greaves, 2015).These were not possible to implement in the present study due to budget constraints, but could be addressed in future studies

Similar to the trial of the 10TT leaflet, the majority of participants in this pilot were white. However, in contrast to the 10TT leaflet RCT, more women and highly educated people took part in this study. This corroborates findings from weight management interventions, which tend to underrepresent men (Pagoto et al., 2012). Also, smartphone ownership tends to be higher among those more affluent and educated (Ernsting et al., 2017; Ofcom, 2016). However, the use of mobile phones has been increasing among lower SES populations, reducing social inequalities for access to evidence-based health apps (Ofcom, 2016). Future studies should also consider recruitment through clinical settings to achieve a more socio-economic balanced sample.

Engagement with the Top Tips app was satisfactory, although there are no references for what would be the ideal engagement to weight loss apps. The app was expected to be accessed every day over 3 months to log achieved tips and current weight, but it was accessed on average 25 times. This is in agreement with a systematic review that suggested that most mobile app interventions for weight loss interventions tend to have high attrition and participants tend to disengage from the app after the first month (Mateo et al., 2015). Also, on average people made plans for half of the tips and most of the tips were achieved less than 3 times over the course of the intervention. The exception was the tip on ‘Caution with portions’, which was achieved on average 8 times, and weight which was logged also on average 8 times. The tip ‘walk off the weight’ was not achieved by anyone. However, this does not mean people did not increase the number of steps because of this intervention, as they might have increased it but not reached the 10k steps recommended per day. The integration of an electronic activity monitor to the app could help to better understand the effect of the intervention on activity behaviours. Overall, this usage pattern suggests that there is room for improvement regarding engagement with the app.

According to users’ feedback, engagement with the app could be increased by making the app more interactive, allowing more tailoring to personal needs and including more resources for weight loss (e.g. recipes). The app's simplicity and design should be maintained, as these were aspects considered positive by users. A recent study highlighted these features as important to keep users engaged, alongside other features such as feedback function, ability to change design to suit own preference, and tailored information (Mateo et al., 2015). In depth focus groups with the target population could also help to better understand the aspects necessary to improve the app.

Although this study was not powered to detect changes or to explore the mechanism of actions, the direction of the results is a preliminary indication that the app worked as expected. For example, participants in both app group conditions improved their eating self-regulatory skills, while no changes were observed in the waiting list group. The effect size varied according to the measure used to assess self-regulation, being smaller for the SREBQ than the adapted SRQ. Compared to the 10TT leaflet trial (Chapter 6, Study 3), which also used the adapted SRQ to assess eating self-regulatory skills, the app groups showed a smaller effect size. However, this may be a consequence of app usage. Users more engaged with the self-regulatory components of the app improved their eating self-regulatory skills to a greater extent, they also had greater adherence to the target behaviours and lost more weight than those who engaged less. This in line with recent evidence suggesting that nutrition and weight loss interventions using self-regulation components tend to be more effective (Dombrowski et al., 2014; Michie et al., 2009). Also, frequency of app use has been related to higher success in changing diet and activity behaviours (Naimark, Madar, & Shahar, 2015).

The amount of weight lost in the app conditions was similar to the weight loss found in a pilot RCT using the 10TT leaflet in a community-based sample, which showed that the 10TT group lost 2 kg, while the waiting list group lost 0.4 kg over 8 weeks (Lally et al., 2008). Similarly, the 10TT leaflet RCT in obese patients from primary care showed that the 10TT group lost 1.68kg over 3 months and this was maintained over 2 years (Beeken et al., 2017). The effect of the Top Tips app on weight loss was promising, but should be taken with caution due to the small sample size. Both the Top Tips only (M=-4.5) and the Top Tips plus (M=-1.9) apps appeared to promote a greater weight loss than the waiting list (M=-0.01) group. However, this should be replicated in a study powered to detect a difference. Also, since the present study only observed the short-term effect, future studies should test the long-term effect of the Top Tips app.

Regarding the effect on target behaviours and dietary intake, both apps showed changes in the expected direction which were in general greater than the waiting list group. Similar to the results in the 10TT leaflet trial, discussed in the previous chapter (Study 3), both apps suggested a medium effect on target behaviour changes over 3 months. However, the effect on changes in F&V, SS, and fat intake were smaller in the app study compared to the 10TT leaflet, representing a small-effect size. Whereas the level of changes in SD intake was small, consistent with that seen in the 10TT leaflet trial.

It was not possible to draw conclusions regarding any differences in impact between the app conditions, although the Top Tips plus app appeared to promote greater absolute decreases in SS and SD intake compared to the Top Tips only app, as expected. However, in contrast, the absolute changes in self-regulatory skills, target behaviours and weight appeared greater in the Top Tips only condition. This may reflect differences in usage between the apps, since participants in the Top Tips only used the app almost twice as much as the Top Tips plus participants. Therefore, the potential additive effect of this new tip on how to deal with tempting food needs further examination to reach a conclusion. Future studies testing the Top Tips app would also benefit from a variety of experimental designs that tease out the main active components within the intervention. For example, a sequential multiple assignment trial (SMART) or a multiphase optimization strategy (MOST) design (Collins, Murphy, & Strecher, 2007).

7.6 Study limitations

The present study had many strengths and limitations. A strength of this study was that the Top Tips app (Top Tips only) contained the same content as the 10TT leaflet, while a new tip was tested in a second version of it (Top Tips plus). However, the mode of delivery of these interventions was different. The Top Tips app intervention was delivered entirely online, while the 10TT leaflet was delivered by health professionals in primary care, and this difference may have impacted the effectiveness of the interventions (Kwasnicka et al., 2016). As a consequence, they should be interpreted as two distinct interventions. On the other hand, the fact that the app intervention was delivered entirely online, with no personal contact, gives a better picture of the potential effect of the new weight loss and habit-based app.

The sample size was small and not powered to detect differences in the outcomes, therefore the results presented may be an overestimation of the real effect. Allocation bias might also have affected the results, since people were not blinded to their condition. Also, as mentioned before, ethnic minorities, men, and people from lower SES backgrounds were under-represented.

There are also limitations related specifically to the current analyses used. The descriptive results for changes in self-regulation, weight, adherence, dietary behaviours should be interpreted only as a preliminary indication of the effect of the app intervention. The study relied on self-report data for weight, diet, behaviour and self-regulation and the limitations related specifically to the measures used are the same as those discussed in previous chapters. Although eating self-regulatory skills were assessed using a valid and reliable measure, it still relies on people's memory and may be subject to social desirability bias. Similar to the previous studies in this thesis, dietary intake was assessed using food frequency questionnaires that rely on individuals' memory. The questions lacked portion size information and did not allow the calculation of overall energy intake. This may have limited the accuracy of the data collected and the understanding of changes in dietary intake. However, the unannounced and self-administered features of these questions combined with the fact that they captured habitual behaviours are important strengths of these measures (Walton, 2015). Furthermore, given the measures used in this study were all self-report, changes in self-regulatory skills, weight, adherence and dietary intake may represent the individuals' perception of change, rather than actual change.

The high percentage of people who did not complete the follow-up questionnaire was also a limitation. Future studies could consider strategies of incorporate the baseline and follow-up assessment into the mobile app. Real-time mobile-based assessment of nutrition, physical activity and behaviours may reduce participant burden and bias (Bruening et al., 2016).

7.7 Conclusions

In conclusion, this chapter's findings suggest that an app version of the 10TT habit-based programme may potentially enhance self-regulatory skills and promote healthy dietary behaviours and weight loss. This suggests that weight loss apps based on habit theory could be cost-effective, flexible and easy to deliver to the target population. Although engagement was moderate, the results indicated that absolute changes in the outcomes increased with app usage, suggesting it worked better among those who engaged with it. According to the users, the Top Tips app could be improved and encourage greater engagement if it had more interactivity and weight loss resources, and allowed for more tailoring to individual needs. The data presented in this study provided sufficient encouragement to develop the app further and test it in greater sample sizes, with more structured recruitment strategies.

CHAPTER 8: GENERAL DISCUSSION AND CONCLUSIONS

8.1 Summary of thesis findings

The overall aim of this thesis was to test the hypothesis that eating self-regulatory skills help to maintain and achieve a healthy diet and weight and can be enhanced through habit-based weight loss interventions. In order to achieve this goal, initially a measure assessing eating self-regulatory skills was developed and validated in the general adult population. I then used different study designs to piece together each part of the picture and provide evidence for the impact of eating self-regulatory skills on weight control and dietary behaviours in various contexts.

The development of the Self-Regulation of Eating Behaviour Questionnaire - SREBQ (Study 1, Chapter 4) provides the first psychometric measure assessing eating-specific self-regulatory skills uniquely and comprehensively in the adult population. The questionnaire is composed of 5 items, encompassing the full range of components involved in the process of self-regulation of eating behaviour described in this thesis (see Chapter 1), such as setting goals, self-monitoring, appraising progress and reviewing and amending goals. The items also assess the ability to control behaviour, thoughts and attention, supporting the SREBQ content validity. Factor structure analyses showed the SREBQ has one underlying factor, which was confirmed in a different sample. The SREBQ was better at assessing self-regulation of eating behaviour than existing general and eating-specific self-regulation measures. Higher SREBQ scores predicted lower BMI, lower sweet and salty snack intake, and higher fruit and vegetable intake in an adult population sample. The SREBQ also showed good convergent validity through strong-to-medium correlations with related constructs (e.g. automaticity, food responsiveness and emotional over-eating) and good discriminant validity, demonstrated by weak correlations with biologically driven appetitive constructs (e.g. satiety responsiveness, food fussiness and slowness in eating). The results showed that this brief and novel questionnaire is consistent, reliable and valid for use in the general UK adult population.

Study 2 (Chapter 5) used this new measure of eating self-regulatory skills to explore the relationship between eating self-regulatory skills, weight and dietary behaviours over 6 months in an online longitudinal cohort of undergraduate students from London, UK. This was the first study to examine eating self-regulatory skills using a valid and reliable scale in this population. As hypothesised, students who entered university with higher eating self-regulatory skills were more likely to maintain or achieve a healthier diet over the course of the first 6 months in university. Higher fruit and vegetable and lower sweet and salty snack intake at the 6-month follow-up were significantly predicted by higher baseline eating self-regulatory skills. Although lower sugary drink intake was also related to higher eating self-regulatory skills, it did not reach the significance cut-off established for this study. Additionally, higher eating self-regulatory skills were related to decreases in weight and lower likelihood of gaining a substantial amount of weight (5% initial body weight) among students with a higher baseline BMI (BMI>21.3kg/m^2). These results suggest that eating self-regulatory skills may be an important ability that protects people against unhealthy behaviour changes and substantial weight gain, especially among people with a higher BMI. Therefore, promoting self-regulatory skills could potentially help students to deal with the transition to university and make healthier decisions as well as control their weight.

As shown in the scoping review presented in Chapter 2, brief weight loss and dietary interventions including planning, self-monitoring and feedback on performance techniques hold promise for promoting self-regulatory skills among overweight and obese adults. However, no evidence of the effect of brief weight loss interventions with a habit formation approach was found. Habit-based interventions are of particular interest because they are considered to be scalable and to promote lasting healthy lifestyles and weight loss. Study 3 (Chapter 6) explored the effect of a habit-based weight loss intervention on eating self-regulatory skills among primary care patients with obesity. This study also aimed to explore the role of eating self-regulatory skill changes on the effectiveness of a habit-based intervention at reducing weight and changing behaviour. Secondary data from the 10 Top Tips

(10TT) habit-based weight loss randomised controlled trial were used. Results showed that over 3 months the 10TT intervention promoted greater changes in self-regulatory skills than Usual care and that these changes mediated the effect of 10TT on target behaviours (dietary, physical activity and self-weighing behaviours) and weight loss. Although other intervention studies based on planning have also shown to be effective at enhancing self-regulatory skills (Kreausukon et al., 2012; Lange et al., 2013; Luszczynska et al., 2007), this is the first study to show that a planning intervention with a habit approach improves self-regulatory skills. Also, this study was the first to provide evidence for the role of eating self-regulatory skills on the mechanism of action of habit-based interventions on weight loss and behaviours in a population-based sample of adults with obesity.

Regarding dietary intake, the 10TT intervention promoted greater improvement in fruit and vegetable consumption than Usual care, and this was also mediated by self-regulatory skills changes. Although sweet snacks, sugary drinks and fat intake decreased significantly in the 10TT condition, no between-group differences were found. The fact that 10TT was designed to help people build new dietary habits may have influenced these results. The addition of self-regulatory skills training specifically focused on breaking habits to the current advice on forming habits could potentially improve the effect of the intervention on unhealthy food intake. Also, as the intervention unsurprisingly worked best when engaged with, the use of novel technologies which is an emerging field in public health, could potentially facilitate self-monitoring and consequently effectiveness.

Based on this, the final study within this thesis (Study 4, Chapter 7) tested some of the suggestions from Study 3. An android mobile application of the 10TT intervention was developed as well as a second version that included brief self-regulatory strategies for dealing with tempting foods. The Top Tips apps were then piloted among adults classified as overweight or obese in order to obtain initial information on usage patterns and effect on self-regulatory skills, weight loss and healthy behaviours. Results from this pilot study suggested that the Top Tips habit-based app might be a useful intervention for promoting eating self-regulatory skills, weight loss and healthy behaviours among overweight and obese adults. The app had a moderate level of engagement, with those engaging more also showing greater absolute changes in self-regulatory skills, weight and adherence to target behaviours. However, it was not possible to draw conclusions regarding the effect of adding self-regulatory training for breaking unhealthy habits to the Top Tips app, and this should be further explored using powered sample sizes and different study designs. Although there are hundreds of commercially available smartphone apps designed to help people lose weight or form habits, most of these are neither theory nor evidence-based (Thomas & Bond, 2014). Therefore, this was the one of the first studies to provide preliminary indications of the usage and effect of a weight loss app intervention based on the habit theory.

The findings from this thesis have a number of theoretical and practical implications and also suggested research questions for further exploration, which are discussed in section 8.2. It is also important to acknowledge the strengths and limitations of the studies included in this thesis. These are outlined in section 8.3.

8.2 Implications for theory, practice and future research

8.2.1 Measuring eating self-regulatory skills

The development of the SREBQ has practical implications for future observational and intervention work. The lack of a standardized and comprehensive measure assessing eating self-regulatory skills in the adult population has limited the possibilities of comparison between studies and the understanding of the role of eating self-regulatory skills on weight control and dietary behaviours. The existing measures of self-regulatory skills do not encompass the full range of components involved in the process of self-regulation of eating behaviour described in this thesis. Also, most of the existing measures are not eating-specific which makes them problematic for assessing self-regulatory skills related to healthy eating. Some measures also include items about weight loss strategies, making them unsuitable for use with the general population. Taking this into account, the development and validation of the 5-item SREBQ filled an important gap. This novel measure is likely to be useful for the assessment of the mechanism of action of dietary and weight control interventions and particularly the effect of interventions that aim to improve eating self-regulatory skills. It may also allow further exploration of relationships between eating self-regulatory skills and other constructs. Moreover, its brevity is a strength as it can be easily included in future observational and intervention studies without substantially increasing participants' burden.

However, as this measure was validated with the UK adult population, future studies should translate and validate it for other populations. Since the development of this questionnaire, some researchers have contacted me to ask if they can use the SREBQ in their research. As a consequence, it has been already translated for use with Mexican-Spanish and Turkish populations. I will also translate and validate it for use with the Brazilian-Portuguese population. This will allow for comparison of studies across countries.

8.2.2 Risk of weight gain and eating self-regulatory skills

The present thesis provided initial evidence for the protective factor of eating self-regulatory skills on individuals' risk of weight gain. Results from Study 2 (Chapter 5) were in line with the suggestion that adults at the higher end of the weight distribution would require more effort to reduce their risk of gaining weight in an obesogenic environment (Kautiainen et al., 2002; Llewellyn & Wardle, 2015; Wardle & Boniface, 2008). However, due to the small proportion of overweight and obese students in this study, these results cannot be conclusive. Future studies should also follow students for the entire period of their degree, in order to ascertain whether this effect persist over the entirety time in university.

Recent research has shown that genetics play a role in individuals' susceptibility to weight gain (Llewellyn & Wardle, 2015). According to the Behavioural Susceptibility Theory, discussed in Chapter 1, the genetic risk to obesity might be expressed in terms of appetitive traits. Results from observational studies have indicated that the association between appetitive traits and weight are stronger among children than adults, suggesting adults might be applying control over their diet and weight (Elks et al., 2012; Hunot et al., 2016). However, this assumption has not been tested empirically and future studies should investigate whether eating self-regulatory skills moderate the relationship between appetitive traits and weight in adults. Also, since multiple genes are related to obesity (Lu & Loos, 2013), with the strongest evidence for *FTO* (Frayling et al., 2007), molecular studies assessing the relationship between genetic predispositions to obesity and eating self-regulatory skills could provide a stronger case for its protective role on the risk of weight gain.

Evidence for this assumption may give rise to another avenue of research – the design an evaluation of interventions seeking to prevent substantial weight gain. For example, targeting eating self-regulatory skills in interventions with undergraduate students has the potential to help them to deal with the dramatic changes in routine, environment and social life experienced during the transition to university. As shown in the scoping review in Chapter 2, there is a lack of studies exploring the effect of enhancing self-regulatory skills on dietary behaviours and weight control in this population, especially among those at the higher end of weight spectrum.

However, there are also other periods where adults are at higher risk of gaining weight. For example, a meta-analysis indicated that smoking cessation is significantly related to a weight gain of 4 to 5 kg over 12 months of abstinence, with the majority of weight gain concentrated in the first 3 months of quitting (Aubin, Farley, Lycett, Lahmek, & Aveyard, 2012). Preventing weight gain in postmenopausal women is also a public health priority, since it increases the risk of breast cancer (Cordina-Duverger et al., 2016). Investigating the preventive effect of self-regulatory skills on weight gain in these two high risk populations is of paramount importance and could inform the development of more effective interventions.

8.2.3 Enhancing eating self-regulatory skills

This thesis showed that brief habit-based weight loss interventions delivered face-to-face or through mobile applications seem to effectively enhance eating self-regulatory skills. However, these interventions were tested only with adults classified as overweight and obese. There is still a need to test the effect of self-regulatory training among the wider population as a means of promoting a healthier diet, as well as in particular populations at risk of weight gain as discussed in the previous section. However, this could be very challenging since not everyone has the intention of having a healthy diet, a pre-requisite of applying eating self-regulatory skills. To address that, the self-regulatory interventions should consider including an initial phase to promote the intention to have a healthy diet. Evidence suggests that the process of increasing motivation to make changes to diet may involve increases in perceived risk of unhealthy behaviours and self-efficacy and outcome expectancies (Schwarzer, 2001). According to the PRIME theory, beliefs need to make people want or need things at the relevant moment in order to influence our behaviour (Michie & West, 2013). Therefore, once people have adopted an intention and have stronger wants and needs of changing their diet, the second phase should come into to play involving self-regulatory skills training to help people achieve their goals and maintain them in the face of obstacles and failures. According to the Health Action Process Approach (HAPPA), promoting self-efficacy would also increase the effectiveness of self-regulatory actions, since it is seen as a stable motivational and volitional determinant (Schwarzer, 1999).

Additionally, improvements in eating self-regulatory skills may be carried over to other behaviours (Annesi, Porter, et al., 2015), promoting a wider health effect. Research conducted by Annesi, Johnson & McEwen (2015) showed that changes in self-regulatory skills in an exercise context was carried over to eating among adults with obesity. This is in line with the suggestion that self-regulatory skills in different domains such as academic performance, financial management and healthy behaviours, are positively related (Bogg & Roberts, 2004; Duckworth & Seligman, 2005; Romal & Kaplan, 1995; Schroder & Schwarzer, 2005). However, this should be further explored using valid and behaviour-specific measures of self-regulatory skills.

8.2.4 Habit formation and eating self-regulatory skills

Findings from Study 3 (Chapter 6) and Study 4 (Chapter 7) elucidated the relevance of eating self-regulatory skills for the effectiveness of a habit-based weight loss intervention. Eating self-regulatory skills appear to be required during the goal striving phase to translate the intended behaviour into action and override unwanted automated responses (Lally & Gardner, 2013; Nederkoorn et al., 2010). This habit formation phase also involves the repetition of the target behaviours in a consistent context to make them become more automatic and habitual (Beeken et al., 2012; Verplanken & Wood, 2006). Recent results from the 10TT trial showed that it promoted increases in automaticity over the first 3 months (Beeken et al., 2017). However, the relationship between automaticity and eating self-regulatory skills within habit-based interventions has not yet been explored. In order to address that, I have analysed whether changes in the automaticity of the target behaviours were also part of the mechanism of action of the 10TT trial on weight loss. The results are presented in one of the papers of this thesis (see Appendix 6.1) and indicated that both changes in self-regulatory skills and changes in automaticity mediated the effect of the intervention on weight loss. However, for this analysis automaticity was assessed using only one item from the 12-item Self-Report Habit Index (Verplanken & Orbell, 2003), and may not be comprehensive enough to assess habit formation. Future studies should consider using the shortened 4-item version of this questionnaire, which has been recently validated (Gardner, Abraham, Lally, & de Bruijn, 2012). In this analysis, automaticity also represented the overall score for the automaticity of all target behaviours. As a consequence, it was not possible to draw conclusions about which behaviours had become habitual. Future studies should aim to explore changes in each of the target behaviours (dietary, activity and self-weighing behaviours) and their automaticity separately. It is important to note that the 10TT results for self-regulation and automaticity are exploratory, since the intervention was not powered to detect changes in these outcomes. Therefore, these results should be confirmed in a powered sample size and also in other populations in order to be more conclusive.

In addition to this, the effect of eating self-regulatory skills and automaticity on the long-term maintenance of dietary and weight changes also remains unclear and should be further evaluated. Studies examining this should target participants that have lost a significant amount of weight (usually over than 3% of initial body weight) and maintained it for at least 6 months (Kwasnicka, Dombrowski, White, & Sniehotta, 2017). Considering that people tend to regain weight over the long term (Curioni & Lourenco, 2005), a greater undestanding of the role of eating self-regulatory skills on weight loss maintenance success would help the design of more effective interventions. Initial evidence of the predictive effect of self-regulation and routine on weight loss maintenance has been provided by a study conducted with 8 individuals using the N-of-1 design (Kwasnicka et al., 2017). This study showed that higher self-regulation and higher routine were associated with greater weight loss plan adherence. However, similar to Studies 3 and 4 (Chapters 6 & 7), Kwasnicka et al. (2017) also measured routine with a single item. Self-regulatory skills were measured using items covering aspects related to biological self-regulation (appetite control) and self-efficacy, missing some relevant aspects of self-regulation of behaviour, such as self-monitoring. As a consequence, there is a need for further studies exploring the role of self-regulatory skills and automaticity on weight loss maintenance using standardised, valid and comprehensive measures.

According to some theorists, as habits are formed, self-regulatory skills would also become more automatic and efficient, requiring less reflective motivational resources (Bargh & Williams, 2006; Marteau et al., 2012). However, there are studies suggesting that cognitions underpinning successful weight loss maintenance are likely to vary over time. Studies using within-people designs, such as n-of-1 design, could potentially enlighten the understanding of the predictors as well as explore under which conditions they vary.

8.2.5 Breaking habits and eating self-regulatory skills

Although the 10TT trial appeared to be effective at decreasing participants' consumption of unhealthy snacks, sugary drinks and fat over 3 months, there were no differences between the 10TT and Usual care conditions in how much these were reduced. This may reflect the focus of 10TT on promoting habit formation. Even though building new habits could potentially help to break unhealthy ones, breaking habits likely requires more effortful self-regulatory skills in order to disrupt cue-response associations (Lally & Gardner, 2013), suppress impulse tendencies toward temptations (Baumeister et al., 2006) and prevent the loss of healthy habits when environmental cues change (Lally et al., 2008). Based on that, Study 4 (Chapter 7) described the development of an app version of the 10TT intervention and also tested the additive effect of the inclusion of strategies for breaking existing habits, such as imagery tasks (Knauper et al., 2011) and intention implementations (Gollwitzer & Sheeran, 2006; Verplanken & Wood, 2006). However, it was not possible to draw firm conclusions regarding the effect of the inclusion of this new tip to 10TT, even though the results were in the expected direction. Future studies using bigger sample sizes and other study designs could potentially help to clarify whether these strategies for dealing with tempting food have an additive effect. Examples of other study designs that hold promise for evaluating e-health interventions are the sequential multiple assignment trial (SMART) or multiphase optimization strategy (MOST) designs (Collins et al., 2007). The SMART design is usually referred to as a time-varying adaptive intervention since the intervention components are tailored to individuals' characteristics and/ or environment, and this tailoring can vary over time. Whereas the MOST design identifies the most effective components within an intervention. This study design consists of three main phases, i) the screening phase, in which the components are selected for inclusion in the intervention; ii) the refining phase, in which the most effective components are selected; and iii) the confirming phase, in which the optimised intervention is tested in a full RCT.

8.2.6 Effective intervention components for enhancing self-regulation

Although this thesis was not focused on identifying the most effective components within the 10TT programme, the understanding of which behaviour change techniques (BCTs) had the greatest impact on eating self-regulatory skills would be relevant for future work. Both interventions, the 10TT leaflet (Study 3; Chapter 6) and Top Tips apps (Study 4; Chapter 7), included a set of components but were evaluated as a package. As a result, some of their components may have had the intended effect, while others may have had no effect at all or may have reduced the effect of the intervention on eating self-regulatory skills, behaviours and weight loss. Therefore, a better understanding of the active ingredients within these interventions would inform the design and evaluation of future intervention work (Michie, Ashford, et al., 2011). The use of the MOST design (Collins et al., 2007) discussed in the previous section could be a useful tool to uncover the techniques that contributed to the intervention effectiveness.

8.2.7 Development of a habit-based intervention that are easily scalable

The use of new technologies to deliver health interventions is still in its early days and more research is required to build a strong body of evidence for the effectiveness of this type of intervention. This thesis provided preliminary evidence of the effect of delivering the 10TT via a mobile app application and suggested that it may also be effective at promoting eating self-regulatory skills, weight loss and healthy dietary behaviours. The level of engagement seemed to be related to greater effect on these outcomes. However, the level of engagement was lower than expected suggesting that there is room for improvement. These results provide sufficient encouragement to develop the app further. The improvement of the app should be guided by the results of focus groups and the users' suggestions from Study 4 (Chapter 7), such as making the app more interactive, allowing more tailoring to personal needs and including more resources for weight loss (e.g. recipes). Additionally, the app should be made available for iOS (Apple's operation system) and accessible via both computers and mobile phones, since this could increase the reach of the intervention and also improve retention (Localytics, 2012; Tang et al., 2015). The improvement of the Top Tips app should be further tested in pilot studies and ultimately in a powered RCT to evaluate the effect of the app on weight and dietary behaviours, as well as its mechanism of action. Real-time mobile-based assessment of nutrition, physical activity and behaviours could be incorporated into the app to reduce participant burden and bias (Bruening et al., 2016). Recruitment through clinical settings should also be considered as it may to achieve a more socio-economic balanced sample.

8.2.8 Sugary drinks and eating self-regulatory skills

The findings for the relationships between eating self-regulatory skills and sugary drinks were not in line with what was expected. Eating self-regulatory skills neither predicted higher sugary drinks intake (Study 1, Chapter 4) in the adult population, nor the maintenance of lower sugary drink intake among undergraduate students (Study 2, Chapter 5). These studies used the same one-item to assess the frequency of sugary drinks intake, which may have limited the accuracy of the dietary intake assessment (this is further discussed in the limitation section 8.3.2). A systematic review has suggested that sugary drinks tend to be consumed in large portion sizes, due to their lower satiety effect compared to solid foods of the same energy density (Malik et al., 2006). Therefore, future studies should explore the effect of eating self-regulatory skills on the amount of sugary drinks consumed, rather than frequency. Nutrition knowledge may have also played a moderator role in this relationship, since people may have not reported their intake accurately due to the lack of understanding of what they should count as sugary drinks, for example, fruit juices.

The findings from the habit-based interventions were also not in line with what was hypothesised. Although the 10TT leaflet and the Top Tips apps seem to have decreased sugary drinks over the course of the intervention, the change was no greater than that observed within the control conditions. Since it was not possible to run mediation analysis for this dietary outcome, it is still not clear whether enhancing eating self-regulatory skills would promote decreases in these dietary behaviours. But as with the observational studies, a potential reason for this might have been the lack of information about portion sizes consumed and low knowledge about the nutritional food composition of drinks and low perceived importance of controlling sugary drinks for weight control.

8.2.9 Policy implications

Although there are still several aspects about the role of self-regulatory skills on weight control and dietary behaviours that need to be further investigated, this thesis provided some initial evidence of the potential of delivering eating self-regulatory skills training in primary care settings or through mobile applications. This may inform policy-makers about the relevance of incorporating eating self-regulatory skills training into public health initiatives aiming to promote healthy dietary behaviours. As a consequence, this might increase the accessibility of this kind of training to the population and potentially enhance the effects of these interventions on dietary behaviours and weight control.

8.3 Strengths and weaknesses

8.3.1 Strengths

The studies in this thesis used a varied of methods to explore the impact of eating self-regulatory skills on weight control and dietary behaviours and the magnitude of the associations were estimated. These relationships were investigated in different contexts and populations, for example in the general adult population as well as in overweight and obese populations, providing consistent results across the studies. Most of the studies were conducted online, a mode of delivery that tends to be more cost-effective and accessible than face-to-face interactions. Ethical approval was granted by the University College London Research Ethics Committee for all studies. Additionally, the studies within this thesis provide a number of advantages over previous research.

Study 1 (Chapter 4) used both quantitative and qualitative studies during the development of the SREBQ. Also, the structure of the SREBQ and its validity and reliability were confirmed in a large and representative sample of adults living in the UK, meeting the requirements suggested by Field (2013) for this kind of study. Study 2 (Chapter 5) used an online prospective and powered sample size to explore eating self-regulatory skills among first year undergraduate students. The approach to recruitment ensured that students from universities representing each of the 7 regions of London and from a range of disciplines were included. Studies 3 & 4 (Chapters 6 & 7) were developed based on habit theory (Lally & Gardner, 2013). The 10TT leaflet intervention (Study 3) was delivered by health professionals from primary care across England, providing direct evidence for its effectiveness in clinical practice. Mediation analyses were performed improving the theoretical understanding of the potential mechanisms of action of habit-based interventions. The delivery of 10TT through a mobile app (Top Tips apps) was tested in Study 4 (Chapter 7), providing early evidence for its effectiveness, usage and acceptability. The fact that the app intervention was delivered entirely online, with no personal contact, was also a strength since it allowed for analysis of the effect of the app only with no potential bias of face-to-face contact. Data collected on dietary intake, target behaviours and self-regulatory skills in both studies were identical, allowing direct comparison. However, there are also some limitations to these studies, which are discussed in section 8.3.2.

8.3.2 Weaknesses

8.3.2.1 SREBQ needs further validation

Although the SREBQ showed good validity and reliability and studies using it showed consisted results, it still requires further validation. There is a need to test the validity of the SREBQ in different populations (e.g. ethnic minorities) and against objective behavioural measures. Also, the construct validity should also be replicated using objective measures of weight and height.

8.3.2.2 Self-report weight and height

The online studies within this thesis (Study 1, 2 & 4) used self-report weight and height data, which may have introduced some inaccuracies. Evidence suggests that people have a tendency to overestimate their height and underestimate their weight and BMI, and this may vary according to gender, age and ethnicity (Danubio, Miranda, Vinciguerra, Vecchi, & Rufo, 2008; Gorber, Tremblay, Moher, & Gorber, 2007). A potential reason for this misclassification is social desirability, when people tend to provide anthropometric data that conform to social norms (Larson, 2000). However, the online samples within this thesis were composed of adults, which according to recent research tend to give a valid online self-reported weight and height (Pursey et al., 2014).

8.3.2.3 Other measurement issues

The measurement of dietary behaviours in the four studies of this thesis was performed using valid food frequency questions. However, they lacked portion size information, were related to groups of foods rather than specific foods, and responses options were based on a Likert scale. They also did not allow the calculation of overall energy intake. This may have limited the accuracy of the data collected and the understanding of changes in dietary intake as well as their relationship with weight loss. As a retrospective measure, these food frequency questions also had the limitation of relying on individuals' memory. However, their unannounced and self-administered features as well as the fact that they capture habitual behaviours are important strengths of this method (Walton, 2015). Additionally, previous studies using these questions have shown that they seem to provide valid data on habitual dietary intake (McGowan et al., 2013; Roe et al., 1994). Future studies looking at associations between self-regulation and dietary intake should use food diaries, a prospective method that assesses the amounts of food and beverage consumed in volume. Although this method could potentially be more expensive and increase participant burden, it would allow the collection of comprehensive and detailed dietary data without relying on participants memory (Walton, 2015).

Studies 3 & 4 (Chapters 6 & 7) also measured the target behaviours (dietary, activity and weighing behaviours) using a single frequency item for each behaviour, which were combined to form a scale of the overall frequency of the target behaviours. However, the validity and reliability of this scale is not known. Also, since the results for the valid and more detailed measures of dietary intake did not show large changes in Study 3, it is possible that the target behaviour scale might have overestimated the effect of 10TT. Furthermore, given these measures were all self-report, changes in dietary intake and target behaviours may represent the individuals' perception of change, rather than actual change.

8.3.2.4 Online recruitment

All data collection for Studies 1, 2 and 4 was online, which means that those without internet access were excluded. During the online recruitment process it was not possible to collect information about how many people actually received the invitation for these studies but chose not to participate. People with a greater interest in nutrition and weight control may have been more likely to take part. The recruitment for Study 2 (Chapter 5) also had other limitations. Many schools and departments did not reply to the request to invite their first year students to take part in the study. Some of them refused to take part because they did not want to burden their students with lots of emails unrelated to their course. There were also restrictions due to the lack of ethical approval from their University, despite the fact that UCL had granted ethical approval for the study. As a consequence, the majority of the students were based at UCL or other universities in central London.

With respect to Study 4 (Chapter 7), almost half of the people interested (40.3%) in the weight loss app study were excluded because the app intervention was only available for Android phones. Among those randomised to the app conditions, about a third did not download the app, suggesting a decrease in interest before even the beginning of the intervention. Future studies should integrate the eligibility criteria and baseline data collection as part of the permission to download the app intervention. This would make the recruitment and randomisation process quicker and could potentially reduce the drop-outs before the beginning of the intervention. Also, the inclusion of face-to-face or telephone support before and after technology-based interventions may increase retention and engagement as well as weight loss (Schippers et al., 2017). Making the app available for iOS (Apple's operation system) could increase the reach of the intervention and also improve retention (Localytics, 2012). Dual phone-computer access could also help increase retention, since other studies suggest it is valued by users (Tang et al., 2015).

8.3.2.5 Engagement to the Top Tips app intervention

The engagement to the app intervention (Study 4) was lower than expected. According to users' feedback, engagement with the app could be increased by making the app more interactive, allowing more tailoring to personal needs and including more resources for weight loss (e.g. recipes). The app's simplicity and design should however be maintained, as these were aspects considered positive by the users. A recent study highlighted these features as important to keep users engaged, alongside other features such as feedback function, ability to change design to suit own preference, tailored information (Mateo et al., 2015). Although users' involvement would have been ideal during this initial development phase of the app, this was not possible due to time and resource constraints. Future studies should aim to include in depth focus groups with the target population in order to better understand the aspects necessary to improve the app. Additionally, since the use of novel technologies is still in its early days, no reference for successful engagement to a weight loss and habit-based app intervention exists. Therefore, the level of engagement found in the 10TT leaflet at 3 months (40%) could be considered a reference point for future studies, although it also brings other limitations due to differences in mode of delivery.

8.3.2.6 Generalisation to other populations

The results presented in this thesis are sample-specific and so cannot be generalised to other populations. For example, the findings regarding the validity and reliability of the SREBQ (Study 1) are limited to the UK adult population. Data for Study 2 (Chapter 5) were only collected from university students based in London. As a consequence, the sample may not be representative of UK first year students, because London tends to have a lower percentage of overweight and obese compared to other regions of the UK (HSCIC, 2015). In fact, overweight and obese individuals were under-represented in the sample, which may explain the modest weight gain found in this study. Men were also under-represented in Study 2, suggesting that the participants who decided to take part in the study may differ from the general student population regarding their interest in a healthy diet and weight control. The 10TT trial (Study 3) was undertaken only with obese adults and therefore the impact of this intervention on eating self-regulatory skills should also be tested in the general population. Ethnic minorities and men were under-represented in this trial and the sample was slightly older compared with the population of adults with obesity described in the Health Survey of England. Similarly, the findings for the Top Tips pilot RCT (Study 4) were limited to overweight and obese adults. The majority of the participants were white, female and highly educated. This corroborates findings from other weight management interventions, which tend to have an underrepresentation of men (Pagoto et al., 2012). Also, smartphone ownership tends to be higher among those more affluent and educated (Ernsting et al., 2017; Ofcom, 2016). However, the use of mobile phones has been increasing among lower SES populations, reducing the gap between social inequalities in the access of evidence-based health apps (Ofcom, 2016). Future studies should consider recruitment through clinical settings to achieve a more socio-economic balanced sample. The app should also be tested in the general population to explore the effect of the intervention among normal weight people.

8.3.2.7 Power to detect differences

Only the study with first year undergraduate students (Study 2; Chapter 5) was powered to detect a significant impact of eating self-regulatory skills on dietary behaviours and weight control. The 10TT leaflet trial (Study 3; Chapter 6) and Top Tips app intervention (Study 4; Chapter 7) were not powered to detect a significant difference in eating self-regulatory skills, dietary intake and target behaviours between the group conditions. Therefore, the results should only be interpreted as exploratory. Although it is recommended that these studies are replicated in studies with larger sample sizes that are powered to detect differences, it is important to note this might be a challenge for studies testing interventions delivered through a mobile app. According to West and Michie (2016) the development of health app interventions is highly iterative and often needs to move to implementation before full trials can estimate effect size. This is because technology changes so rapidly that the time required to test healthcare interventions in a pilot followed by full RCT might be too long to be useful.

8.3.2.8 Lack of long-term evaluations

The long-term effect of eating self-regulatory skills on dietary behaviours and weight control was not assessed. In Study 2 (Chapter 5), follow-up data were collected at the end of the first 6 months at university. However, the effect of self-regulatory skills on weight gain prevention and healthy dietary behaviours over the entire period at university is still not clear. Additionally, for both Study 3 (Chapter 6) and Study 4 (Chapter 7) the active intervention period was the first 3 months, and follow-up data were collected at the end of this period. The impact of habit-based interventions on eating self-regulatory skills over the long-term is not known, neither whether enhancing eating self-regulatory skills would also help to maintain weight loss and healthy dietary behaviours changes. Future studies should assess the long-term impact of eating self-regulatory skills on weight control and dietary behaviours.

8.3.2.9 Missing data

Missing data in both the 10TT leaflet trial (Study 3; Chapter 6) and Top Tips app intervention pilot (Study 4; Chapter 7) may have led to biases, although the sensitivity analyses indicated otherwise. In the 10TT leaflet trial (Study 3; Chapter 6) the analysis of the pathways was missing data for the variables of interest (compromising internal validity) and of course nullifying randomisation so that the results are more in keeping with that of a cohort study analysis than a RCT. Whereas in the Top Tips app pilot (Study 4; Chapter 7), the high percentage of people not completing the follow-up questionnaire compromised the ability to assess the effect of the intervention on the outcome variables. Future studies could consider strategies to incorporate the baseline and follow-up assessment into the mobile app. Real-time mobile-based assessment of nutrition, physical activity and behaviours may also reduce participants' burden and bias (Bruening et al., 2016).

8.4 Conclusion

The overall aim of this thesis was to test the assumption that eating self-regulatory skills are relevant to maintain and achieve a healthy diet and weight and can be enhanced through habit-based weight loss interventions. The Self-Regulation of Eating Behaviour Questionnaire (SREBQ) was developed and validated to allow the testing of this thesis' hypothesis using different study designs. Taken together, the findings from this thesis suggest that eating self-regulatory skills help to maintain and achieve a healthy diet and protect against substantial weight gain, especially among individuals with a higher BMI. This thesis also suggests that eating self-regulatory skills can potentially be enhanced through habit-based weight loss interventions delivered face-to-face or via mobile app. Changes in self-regulation seem to be the underlying mechanism by which habit-based interventions promote target health behaviours, which in turn promotes greater weight loss in adults with obesity. Thus, targeting eating self-regulatory training in weight loss and dietary interventions seems to be a promising approach for the prevention and treatment of obesity and promotion of a healthy diet in the adult population. The preliminary testing of the Top Tips app, a habit-based weight loss intervention, provided sufficient encouragement to develop it further and explore its impact on eating self-regulatory skills, weight control and dietary behaviours, paving the way for future research.

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Appendix 1.1 Glossary

Appetitive traits: a set of stable predispositions towards food (Carnell & Wardle, 2008).

Behaviour: defined as ‘anything a person does in response to internal or external events’ (Michie & West, 2013).

Behavioural inhibition: ability to actively inhibit behaviour and impulses that do not conform to their standards (Baumeister et al., 2006; Hofmann, Baumeister, et al., 2012)

Coping plan: the mental link between the anticipated obstacle and the behavioural response (Sniehotta et al., 2005)

Dietary restraint: the intention to restrict food intake in order to control body weight (Herman & Mack, 1975).

Disinhibition: the tendency to overconsume in response to a stimulus, such as emotional distress or the presence of tempting foods (Hays & Roberts, 2008).

Eating self-regulatory skills: individual’s ability to manage their eating behaviour and override their natural impulses toward tempting foods in order to achieve and maintain a healthy diet and weight.

Ego Depletion: as a result of prior engagement in self-control effort, people become temporarily vulnerable to self-regulatory failure in their subsequent self-control attempt (Baumeister, 2016; Baumeister et al., 2007).

Executive function: the cognitive abilities required for action planning, strategy development, flexible behaviour, maintenance of behaviour and resistance of interferences (Barkley, 2001; Blair & Ursache, 2011).

Food responsiveness: the response to external food cues such as the sight or smell of food (Carnell et al., 2008)

Habit The automatic process that generates an impulse toward action, based on learned stimulus-response association (Gardner, 2015)

Mental shifting: ability to adjust personal goals and action plans flexibly to changing circumstances (Hofmann et al., 2011)

Restraint theory: cognitive control over eating behaviour may result in overeating in situations where control is undermined, referred to as ‘counter-regulation’ (Annesi, Porter, et al., 2015; Cools et al., 1992; Herman & Mack, 1975; Herman & Polivy, 1975; Hibscher & Herman, 1977).

Satiety sensitivity: ability to recognise and respond to internal sensations of fullness or satiety (Carnell & Wardle, 2008)

Self-control: the ability to inhibit dominant responses tendencies or desires in order to attain a personal goal (Carver & Scheier, 2011; de Ridder et al., 2012).

Self-management: the application of processes of self-regulation (Monique Boekaerts et al., 2005).

Self-regulatory skills: Individual's ability to alter their behaviour, thoughts, feelings, attention and environment in the pursuit of their personal goals (Boekaerts, Maes, & Karoly, 2005; Carver & Scheier, 2001; De Vet et al., 2014; Moilanen, 2007).

Self-efficacy: people's belief in their capacity to achieve a goal, on self-regulatory actions (Bandura, 1991).

Skills: are defined as an ability or proficiency acquired through practice (Cane, O'Connor & Michie, 2012).

Working memory: ability to maintain and update relevant mental representations of goals or strategies and shield this information from distraction. It is relevant for the regulation of thoughts and attention (Hofmann, Schmeichel, et al., 2012).

Appendix 2.1 Search strategy

Advanced searched on PubMed, Web of Science, Scopus and PsycInfo was performed using the search strategy below, limiting to paper published from 2007:

	Index Terms	**Field**
And	“self-regulat*” or “self-control” or “self-management” or “impulsiv*”	Title or Abstract
And	“questionnaire” or “scale” or “measure” or “instrument”	Title or Abstract
And	“eating” or “nutrition” or “food” or “weight”	Title or Abstract
And	“adult” or “adolescent” or “student”	Title or Abstract

Appendix 3.1 List of publications and conferences

1) Papers

Published papers directly related to my thesis:

Kliemann N., Vickerstaff, V., Croker, H., Johnson F., Nazareth, I., Beeken R. The role of self-regulatory skills and automaticity on the effectiveness of a brief weight loss habit-based intervention: secondary analysis of the 10 Top Tips Trial (2017). International Journal of Behavioural Nutrition and Physical Activity.

Kliemann, N., Beeken, R. J., Wardle, J., & Johnson, F. (2016). Development and validation of the Self-Regulation of Eating Behaviour Questionnaire for adults. International Journal of Behavioral Nutrition and Physical Activity, 13.

Kliemann, N., Vickerstaff, V., Croker, H., Johnson, F., & Beeken, R. J. (2016). Increases in Self-Regulatory Skills and Automaticity Mediate the Effect of a Habit Based Intervention on Weight Loss. International Journal of Behavioral Medicine, 23, S66-S66.

Other published papers, results of collaborations during my PhD :

Kliemann N, Wardle J, Johnson F, Croker H. Reliability and validity of a revised version of the General Nutrition Knowledge Questionnaire. European Journal of Clinical Nutrition**,** 2016, 70(10): 1174-1180.

Hardy, R., **Kliemann, N.**, Evansen, T., & Brand, J. (2017). Relationship Between Energy Drink Consumption and Nutrition Knowledge in Student-Athletes. Journal of Nutrition Education and Behavior, 49(1):19-26.

Papers under review:

Kliemann, N., Croker, H., Johnson, F. & Beeken, R. J. (2017). Eating self-regulatory skills in first year undergraduate students: relationships with weight and dietary changes. *Journal of the Academy of Nutrition and Dietetics*.

2) Conferences

Oral presentations:

Kliemann N, Vickerstaff V, Croker H, Johnson F, Beeken R. Increases in self-regulatory skills and automaticity mediate the effect of a habit-based intervention on weight loss. International Congress of Behavioral Medicine. 7th to 10th December 2016, Melbourne, Australia.

Beeken R, **Kliemann N**, Vickerstaff V, Croker H, Johnson F. Promoting cancer prevention through a habit-based intervention: effects on self-regulatory skills, automaticity and weight loss. World Cancer Congress. 31st October to 3rd November 2016, Paris, France.

Kliemann N, Beeken R, Johnson F. Development, Reliability and Validity of the Self-Regulation of Eating Behaviour Questionnaire (SREBQ) for Adults. VIII ABEP Conference. 13th to 14th May 2016 at King's College London, UK.

Kliemann N. Effect of the 10 Top Tips habit-based intervention on self-regulatory skills and automaticity and its impact on weight loss. Health Behaviour Research Centre and Psychobiology Group Away Day Conference. 15th July 2016, London, UK.

Kliemann N, Wardle J, Johnson F. Development and validation of the Self-Regulation of Eating Behaviour Questionnaire for adults. UK Congress on Obesity. 9th to 11th September 2015, Glasgow, UK.

Poster presentations:

Kliemann N, Wardle J, Croker H. Development and validation of the General Nutrition Knowledge Questionnaire-Revised for adults. UK Congress on Obesity - UKCO2015. 9th to 11th September 2015, Glasgow, UK.

Appendix 4.1 Paper published in IJBNPA

Kliemann *et al. International Journal of Behavioral Nutrition and Physical Activity* (2016) 13:87
DOI 10.1186/s12966-016-0414-6

International Journal of Behavioral Nutrition and Physical Activity

METHODOLOGY Open Access

Development and validation of the Self-Regulation of Eating Behaviour Questionnaire for adults

Nathalie Kliemann, Rebecca J. Beeken, Jane Wardle and Fiona Johnson*

Abstract

Background: Eating self-regulatory capacity can help individuals to cope with the obesogenic environment and achieve, as well as maintain, a healthy weight and diet. At present, there is no comprehensive, reliable and valid questionnaire for assessing this capacity and measuring change in response to self-regulation interventions in adults. This paper reports the development of the Self-regulation of Eating Behaviour Questionnaire (SREBQ) for use in UK adults, and presents evidence for its reliability and construct validity.
The development of the SREBQ involved generation of an item pool, followed by two pilot studies (Samples 1 and 2) and a test of the questionnaire's underlying factor structure (Sample 3). The final version of the SREBQ was then assessed for reliability and construct validity (Sample 4).

Results: Development of the SREBQ resulted in a 5-item questionnaire. The face validity was satisfactory, as assessed by the pilot studies. The factor structure analysis (Sample 3) suggested that it has a single underlying factor, which was confirmed in a second sample (Sample 4). The SREBQ had strong construct validity, showing a positive correlation with general measures of self-regulation. It was also positively correlated with motivation and behavioural automaticity, and negatively correlated with food responsiveness and emotional over-eating ($p < 0.001$). It showed good discriminant validity, as it was only weakly associated with satiety responsiveness, food fussiness and slowness in eating.

Conclusions: The SREBQ is a reliable and valid measure for assessment of eating self-regulatory capacity in the general UK adult population.

Keywords: Measurement, Questionnaire, Self-regulation, Self-control, Eating behaviour, Validity, Reliability

Background

Changes in dietary and physical activity patterns, largely attributable to environmental changes, promote a positive energy balance in many populations [1]. However, environmental cues to eat do not affect all people similarly and there is a need to understand individual-level factors that determine vulnerability to the development of obesity [2]. In recent years, it has been suggested that the capacity to self-regulate eating behaviours may moderate individual susceptibility to the obesogenic environment and support the maintenance of a healthy weight and diet [3, 4]. Behavioural self-regulation is likely to be a relatively stable construct [5], but one that can be improved through practice [3, 6]. As a consequence, interventions promoting self-regulation training may have the potential to support successful weight control [7] and the formation of healthy dietary habits [8]. In order to test this and to determine the effectiveness of interventions it is imperative to have a valid and reliable measure of eating self-regulatory capacity. However, at present no established and standardized self-report measures exist to assess eating self-regulatory skills in the adult population. The aim of this study was to address this gap by developing and validating a measure of eating self-regulatory capacity for adults.

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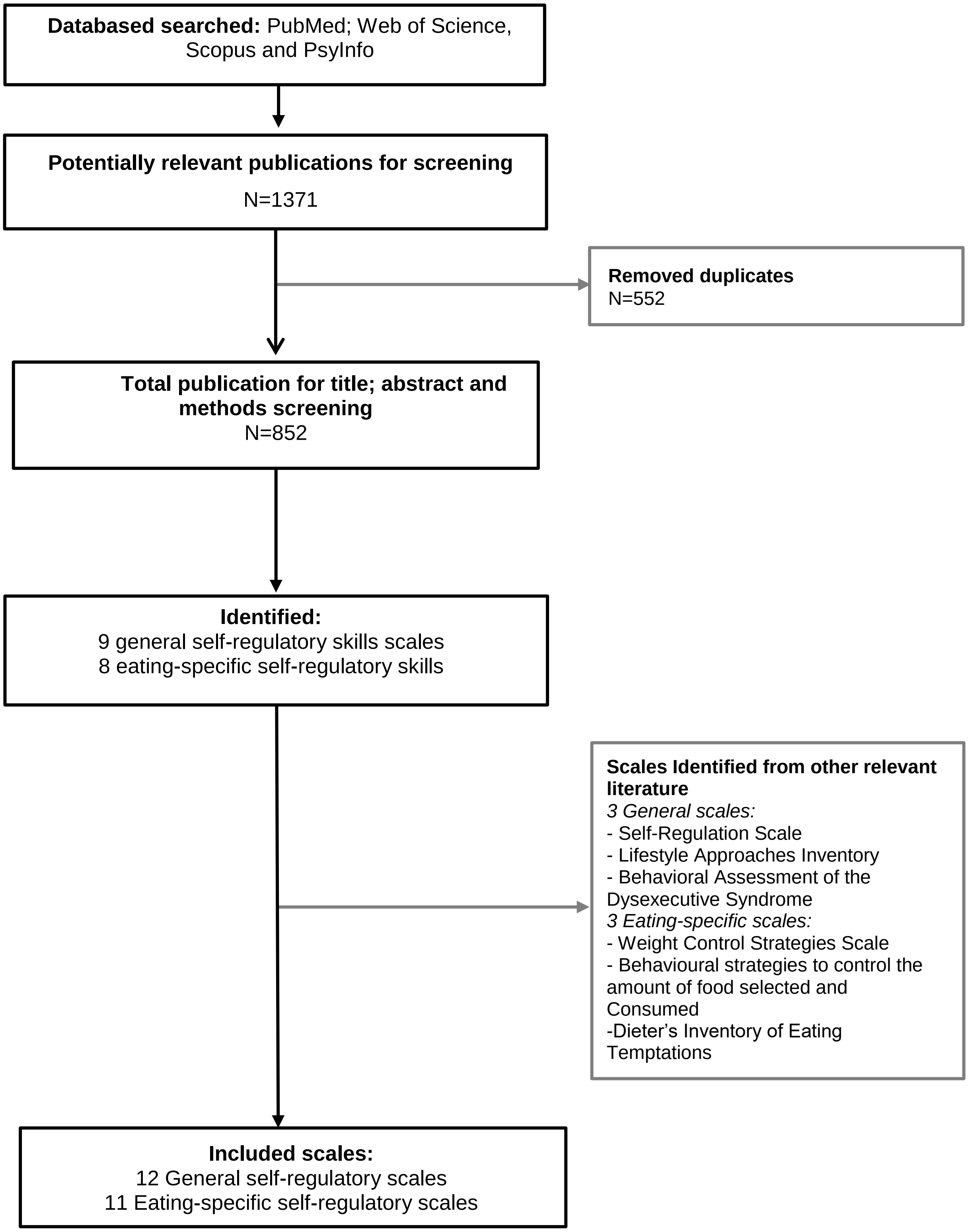
Appendix 4.2 Search strategy

Advanced searched on PubMed, Web of Science, Scopus and PsyInfo was performed using the search strategy below, limiting to paper published until 2014:

	Index Terms	**Field**
And	self-regulat*" or "self-control" or "self-management" OR impulsiv*	Title or Abstract
And	questionnaire" or "scale" or "measure" or "instrument"	Title or Abstract
And	"eating" or "nutrition" or "food" or "weight"	Title or Abstract
And	"reliability" or "valid*" or "development"	Title or Abstract

Appendix 4.3 Flow diagram of search results



Appendix 4.4 Survey of the Pilot Study 1

Self-Regulation of Eating Behaviour Questionnaire (SREBQ)

1. Do you find any of these foods tempting (that is, do you want to eat more of them than you think you should)?

	Yes	No		Yes	No
Chocolate	☐	☐	Sweets	☐	☐
Crisps	☐	☐	Popcorn	☐	☐
Cakes	☐	☐	Pastries	☐	☐
Ice cream	☐	☐	Pizza	☐	☐
Bread	☐	☐	Fried foods	☐	☐
Fizzy drinks	☐	☐	Chips	☐	☐
Biscuits	☐	☐	Other(s)	☐	☐
			Please specify:		

2. Do you try to reduce your consumption of any of these foods?

Yes ☐ No ☐

3. Do you try to eat more healthy foods (e.g. fruit and vegetables)?

Yes ☐ No ☐

If you said yes for questions 2 and/or 3, the next questions are about how do you do.

4. Which of these foods do you try to cut down on?

Chocolates	☐	Biscuits	☐
Crisps	☐	Sweets	☐
Cakes	☐	Popcorn	☐
Ice Cream	☐	Pastries	☐
Bread	☐	Pizza	☐
Fizzy drinks	☐	Fried foods	☐
Chips	☐	Other	☐
		Please specify:	

For the next questions, please understand 'tempting food' as any foods that you try to cut down on.

	How often do you…	Never	Rarely	Sometimes	Often	Always
1.	set goals to eat healthily	☐	☐	☐	☐	☐
2.	set goals to avoid tempting food	☐	☐	☐	☐	☐
3.	find it hard to set eating goals for yourself (reverse)	☐	☐	☐	☐	☐
4.	make a list of eating goals for yourself	☐	☐	☐	☐	☐
5.	make a detailed plan regarding when to start making changes	☐	☐	☐	☐	☐
6.	make a detailed plan regarding how to improve your diet	☐	☐	☐	☐	☐
7.	plan how often you are going to eat some foods	☐	☐	☐	☐	☐
8.	plan to bring a piece of fruit to school/work every day	☐	☐	☐	☐	☐
9.	make clear plans to control your diet	☐	☐	☐	☐	☐
10.	come up with ways to make your diet healthier	☐	☐	☐	☐	☐
11.	have trouble making eating plans to help you reach your goals (reverse)	☐	☐	☐	☐	☐
12.	put off making decisions about your diet (reverse)	☐	☐	☐	☐	☐
13.	intentionally choose a healthy food, when you want to eat a tempting food	☐	☐	☐	☐	☐
14.	intentionally keep yourself busy when you are hungry before a meal	☐	☐	☐	☐	☐
15.	intentionally do not overdo it when eating	☐	☐	☐	☐	☐
16.	intentionally eat a tempting food very slowly	☐	☐	☐	☐	☐
17.	remember that tempting foods are bad for your health, when you want to eat them	☐	☐	☐	☐	☐
18.	remember your eating intentions, when faced with tempting food	☐	☐	☐	☐	☐
19.	concentrate on appreciating what you are eating	☐	☐	☐	☐	☐
20.	tell yourself that one lapse doesn't mean that all is lost	☐	☐	☐	☐	☐
21.	comfort yourself with something you like to do (e.g. watch a movie) rather than food, when you are stressed or tired	☐	☐	☐	☐	☐
22.	have plans for what to do in difficult situations in order to stick to your eating intentions	☐	☐	☐	☐	☐
23.	have snacks and sweets you've been avoiding at home	☐	☐	☐	☐	☐

24.	avoid the aisle with sweets and chocolates, when you go to the supermarket	☐	☐	☐	☐	☐
25.	take a little bit and put the rest out of the sight, when you want to have a treat	☐	☐	☐	☐	☐
26.	ignore the food If you go to a party with lots of snacks	☐	☐	☐	☐	☐
27.	remember that you want to eat healthily when you want to have a treat	☐	☐	☐	☐	☐
28.	distract yourself when you feel like buying tempting foods	☐	☐	☐	☐	☐
29.	avoid eating in front of the television	☐	☐	☐	☐	☐
30.	consciously eat less for a period of time to make up for it, after eating a food you were avoiding	☐	☐	☐	☐	☐
31.	come up with ways to overcome the barriers to healthy eating	☐	☐	☐	☐	☐
32.	find ways to avoid tempting foods	☐	☐	☐	☐	☐
33.	tell yourself “no!” to unhealthy foods	☐	☐	☐	☐	☐
34.	find it hard to overcome problems that prevent you controlling your diet (reverse)	☐	☐	☐	☐	☐
35.	eat what you have planned throughout the day	☐	☐	☐	☐	☐
36.	stick to a eating plan that’s working well	☐	☐	☐	☐	☐
37.	stay focused on your eating intentions even when it’s dull	☐	☐	☐	☐	☐
38.	find ways to make yourself eat healthily even when you are in tempting situations	☐	☐	☐	☐	☐
39.	find ways to make yourself eat healthily even when it is tough	☐	☐	☐	☐	☐
40.	resist eating something when you know you shouldn’t	☐	☐	☐	☐	☐
41.	meet your eating goals	☐	☐	☐	☐	☐
42.	get distracted from your long-term eating goals (reverse)	☐	☐	☐	☐	☐
43.	forget your eating goals, when you are in front of lots of tempting foods (reverse)	☐	☐	☐	☐	☐
44.	think you should try harder to follow your eating intentions (reverse)	☐	☐	☐	☐	☐
45.	give up on your eating intentions because you are sad (reverse)	☐	☐	☐	☐	☐
46.	give up on your eating plan because it gets boring (reverse)	☐	☐	☐	☐	☐
47.	ignore your eating intentions if you are hungry and immediately have to eat something (reverse)	☐	☐	☐	☐	☐
48.	have trouble forcing yourself to choose healthy food in tempting situations (reverse)	☐	☐	☐	☐	☐
49.	keep track of whether you are carrying out your eating intentions	☐	☐	☐	☐	☐
50.	keep a diary of the foods you have eaten	☐	☐	☐	☐	☐
51.	keep track of your eating, even when you are feeling stressed	☐	☐	☐	☐	☐
52.	make sure you track your progress regularly when you are working towards an eating goal	☐	☐	☐	☐	☐
53.	think about how you are doing with your eating intentions	☐	☐	☐	☐	☐
54.	consistently monitor your diet throughout the day	☐	☐	☐	☐	☐
55.	check whether you eat exactly as you have planned	☐	☐	☐	☐	☐
56.	Find it hard to monitor your eating throughout the day (reverse)	☐	☐	☐	☐	☐
57.	Find it hard to track your progress towards your eating goals (reverse)	☐	☐	☐	☐	☐
58.	do something to change your eating as soon as you see things aren’t going right with it	☐	☐	☐	☐	☐
59.	start looking for possible solutions as soon as you see a problem or challenge	☐	☐	☐	☐	☐
60.	change the ways you do things when you see a problem with how things are going with your diet	☐	☐	☐	☐	☐
61.	change your actions to try and reach your goals if something isn’t going according to your plans	☐	☐	☐	☐	☐
62.	find a way to change your eating plans when they are not working	☐	☐	☐	☐	☐
63.	find it hard to change ways of doing things (reverse)	☐	☐	☐	☐	☐
64.	give up on my eating plans when they are not working (reverse)	☐	☐	☐	☐	☐

Comments:

We are also interested in whether people actually define eating goals for themselves and whether they can identify them and reflect on them.

1. Can you identify any eating goals that you set for yourself?

Yes ☐ No ☐

2. What are they?

3. What is the timescale of them i.e are they goals for one eating episode, a day/week month/longer?

Appendix 4.5 Survey of the Pilot Study 2

Thank you for your interest in our research.

The aim of this research is to validate a questionnaire that can be used to assess people's self-regulation of eating behaviour (what people do to control their eating and to reach their eating goals). In total the survey will take about 10 minutes of your time to complete. We understand that some of the questions are a little repetitive, but we are using this process to filter out questions that will be eliminated.

All responses to this questionnaire are anonymous, so we won't be able to respond directly to any answers.

If you have any further questions about the study, please do not hesitate to send an email to Nathalie Kliemann: **nathalie.kliemann.13@ucl.ac.uk**

If you are happy to take part, please click on 'Next' below. By clicking on "Next" you are agreeing that:

- You have read the notes written above and you understand what the survey involves.
- You understand that as your participation is anonymous it will not be possible for us to withdraw your responses once you have completed the survey.
- The project has been explained to you and that you agree to take part in the survey.

1. Are you

Male ☐

Female ☐

2. How old are you?

[ ]

3. What is your current weight approximately? Please give this in stones or kilograms.

Kilograms [ ]

Or Stones [ ]

Pounds [ ]

4. What is your height approximately? Please give this in feet and inches or centimetres.

Centimetres [ ]

Or Feet [ ]

Inches [ ]

5. Do you find any of these foods tempting (that is, do you want to eat more of them than you think you should)? (tick those which apply)

	Yes	No
Chocolate	☐	☐
Crisps	☐	☐
Cakes	☐	☐
Ice cream	☐	☐
Bread/toast	☐	☐
Soft drinks	☐	☐
Biscuits	☐	☐
Sweets	☐	☐
Popcorn	☐	☐
Pastries	☐	☐
Pizza	☐	☐
Fried foods	☐	☐
Chips	☐	☐

Others (please specify): [ ]

6. Do you try to ensure that you don't eat too much of these tempting foods?

Yes ☐

No ☐

7. Do you try to ensure you include lots of healthy foods (e.g. fruit and vegetables) in your diet?

Yes ☐

No ☐

8. For the following questions, please consider 'tempting foods' to be any foods that you described as tempting in the previous question

	Never	Rarely	Sometimes	Often	Always
1. I plan how often I am going to eat some foods.	□	□	□	□	□
2. I make clear plans to control my diet.	□	□	□	□	□
3. I come up with ways to make my diet healthier.	□	□	□	□	□
4. I have trouble making eating plans to help me reach my goals.	□	□	□	□	□
5. I put off making decisions about my diet.	□	□	□	□	□
6. I have a target weight for myself.	□	□	□	□	□
7. I remember my eating intentions, when faced with tempting food.	□	□	□	□	□
8. I concentrate on appreciating what I am eating.	□	□	□	□	□
9. I have plans for what to do in difficult situations in order to stick to my eating intentions.	□	□	□	□	□
10. I remember that I want to eat healthily when I am tempted to have a treat.	□	□	□	□	□
11. I distract myself when I feel like buying tempting foods.	□	□	□	□	□
12. I avoid eating in front of the television.	□	□	□	□	□
13. I remember the taste of the foods when faced with tempting foods.	□	□	□	□	□
14. I find it hard to overcome problems that prevent me controlling my diet.	□	□	□	□	□
15. I know what to do when I am feeling emotionally distressed, in order to stick to my eating goals.	□	□	□	□	□
16. I keep healthy food at home.	□	□	□	□	□
17. I avoid the aisle with sweets and chocolates, when I go to the supermarket.	□	□	□	□	□
18. I remember that tempting food are bad for my health, when I want to eat them.	□	□	□	□	□
19. I tell myself that one lapse doesn't mean that all is lost.	□	□	□	□	□
20. I have snacks and sweets I am avoiding at home.	□	□	□	□	□
21. I look at food label before deciding which food I'll buy.	□	□	□	□	□
22. I choose smaller portion sizes when I want to have a tempting food.	□	□	□	□	□
23. I eat what I have planned throughout the day.	□	□	□	□	□
24. I stick to a eating plan that's working well.	□	□	□	□	□
25. I stay focused on my eating intentions even when it's dull.	□	□	□	□	□
26. I'm good at resisting tempting food	□	□	□	□	□
27. I meet my eating goals.	□	□	□	□	□
28. I easily get distracted from my eating goals.	□	□	□	□	□
29. I forget my eating goals, when I am in front of lots of tempting foods.	□	□	□	□	□
30. When there is tempting food around I eat it even if I am not hungry.	□	□	□	□	□
31. I have trouble forcing myself to choose healthy food in tempting situations.	□	□	□	□	□
32. I meet my weight goals.	□	□	□	□	□

33. I put aside my eating goals in order to concentrate on other activities.	□	□	□	□	□
34. I eat my meals at the same time throughout each day.	□	□	□	□	□
35. I have a hard time breaking bad eating habits.	□	□	□	□	□
36. I eat tempting food without meaning to.	□	□	□	□	□
37. I refuse tempting foods, even if they are delicious.	□	□	□	□	□
38. People would say that I have very strong self-discipline when it comes to food.	□	□	□	□	□
39. Pleasure and fun keep me from getting work done.	□	□	□	□	□
40. I eat things that taste good in the moment but regret it later on.	□	□	□	□	□
41. I can't stop myself from eating something, even if I know I should resist.	□	□	□	□	□
42. I eat tempting food without thinking through all the alternatives.	□	□	□	□	□
43. I keep track of my eating, even when I am feeling stressed.	□	□	□	□	□
44. I make sure I track my progress regularly when I am working towards an eating goal.	□	□	□	□	□
45. I consistently monitor my diet throughout the day.	□	□	□	□	□
46. I find it hard to monitor my eating throughout the day.	□	□	□	□	□
47. I find it hard to track my progress towards my eating goals.	□	□	□	□	□
48. I weigh myself.	□	□	□	□	□
49. I compare my diet/weight with other people's diet/weight.	□	□	□	□	□
50. I keep a diary of the foods I have eaten.	□	□	□	□	□
51. I start looking for possible solutions as soon as I see a problem or challenge.	□	□	□	□	□
52. I change the ways I do things when I see a problem with how things are going with my diet.	□	□	□	□	□
53. I find a way to change my eating plans when they are not working.	□	□	□	□	□
54. I find it hard to change ways of doing things.	□	□	□	□	□
55. I give up on my eating plans when they are not working.	□	□	□	□	□
56. I change my diet when I see a problem with my weight.	□	□	□	□	□
57. I seek help from experts, magazines or books for weight or eating problems.	□	□	□	□	□

We are also interested in whether people actually define eating goals for themselves and whether they can identify them and reflect on them.

9. Can you identify any eating goals that you set for yourself?

Yes ☐

No ☐

10. What are they?

11. What is the timescale of them i.e are they goals for one eating episode, a day/week month/longer?

12. Are there any other things you usually do in order to control your eating that weren't mentioned in the questionnaire?

Yes ☐

No ☐

13. What are they?

14. Overall, how easy or difficult did you find the questions in the survey?

Very easy ☐
Quite easy ☐
Not sure ☐
Quite difficult ☐
Very difficult ☐

15. If you have said quite or very difficult, please tell us why and what types of questions/ topics you found particularly difficult?

16. Did you find any of the questions offensive or displeasing?

Yes ☐

No ☐

17. If yes, please tell us which questions/ topics you found offensive or displeasing and say why?

18. This survey is designed to assess people's self-regulation of eating behaviour (what people do to control their eating and to reach their eating goals). Do you think we have adequately covered the different aspects of self-regulation of eating behaviour?

Yes ☐

No ☐

19. If not, what else do you think we should have asked about to assess people's self-regulation of eating behaviour?

Appendix 4.6 Survey of the 'Internal Reliability and Factor Structure Study'

Thank you for your interest in our research.

The aim of this research is to design a questionnaire to assess 'self-regulation of eating behaviour' (how easy people find it to control and manage their eating). In total the survey will take about 15 minutes of your time to complete.

Participants will be eligible to enter a prize draw to win a £25 M&S voucher.

All responses to this questionnaire are confidential and your responses will not be linked to any identifying information.

If you have any further questions about the study, please do not hesitate to send an email to Nathalie Kliemann: **nathalie.kliemann.13@ucl.ac.uk**

If you are happy to take part, please click on 'Next' below. By clicking on "Next" you are agreeing that:

- You have read the notes written above and you understand what the survey involves.
- You understand that as your participation is anonymous it will not be possible for us to withdraw your responses once you have completed the survey.
- The project has been explained to you and that you agree to take part in the survey.

1. Do you find any of these foods tempting (that is, do you want to eat more of them than you think you should)? (tick those which apply)

	Yes
Chocolate	☐
Crisps	☐
Cakes	☐
Ice cream	☐
Bread/toast	☐
Fizzy drinks	☐
Biscuits	☐
Sweets	☐
Popcorn	☐
Pastries	☐
Pizza	☐
Fried foods	☐
Chips	☐

Others (please specify): ☐

2. Do you try not to eat too much of these tempting foods?

Yes ☐

No ☐

3. Do you intend to ensure you include lots of healthy foods (e.g. fruit and vegetables) in your diet?

Yes ☐

No ☐

4. For the following questions:

- **'Tempting foods' are any foods you described as tempting**
- **'Eating intentions' refer to the way you intend to eat (e.g avoiding tempting foods and/or eating healthily**

	Never	Rarely	Sometimes	Often	Always
1. When I want to change the way I eat I get started straight away	☐	☐	☐	☐	☐
2. Situations come up which stop me eating the way I intend to	☐	☐	☐	☐	☐
3. Thinking about eating healthily or controlling my weight helps me avoid eating tempting food	☐	☐	☐	☐	☐
4. I'm good at resisting tempting food	☐	☐	☐	☐	☐
5. I stick to my eating plans even when I am feeling upset or stressed	☐	☐	☐	☐	☐

6. When I am with certain people I find it difficult to eat the way I intend to	□	□	□	□	□
7. I can stick to an eating plan that's working well	□	□	□	□	□
8. I stay focused on my eating intentions even when it's dull	□	□	□	□	□
9. Thinking about my plans to eat healthily or control my weight helps me resist the temptation to have a treat.	□	□	□	□	□
10. Most days I manage to stick to my eating plans	□	□	□	□	□
11. I easily get distracted from my eating intentions	□	□	□	□	□
12. When I am in front of tempting food I forget that I intend to eat healthily or control my weight	□	□	□	□	□
13. When there is tempting food around I eat it even if I am not hungry	□	□	□	□	□
14. I have trouble making myself choose healthy food in tempting situations	□	□	□	□	□
15. It is difficult for me to break bad eating habits	□	□	□	□	□
16. I eat tempting food without meaning to	□	□	□	□	□
17. I usually refuse tempting food even if it is delicious	□	□	□	□	□
18. People would say that I have strong self-discipline when it comes to food	□	□	□	□	□
19. I eat things that taste good at the time, then regret it later on	□	□	□	□	□
20. When I want something tempting, I only have a small amount	□	□	□	□	□
21. I eat tempting food without thinking through the alternatives	□	□	□	□	□
22. I am good at keeping track of my eating even when I am feeling stressed or upset	□	□	□	□	□
23. I change the ways I do things when I see a problem with how things are going with my diet	□	□	□	□	□
24. I find a way to change my eating plans when they are not working	□	□	□	□	□
25. I find it hard to control my eating	□	□	□	□	□
26. I give up too easily on my eating plans	□	□	□	□	□
27. I notice straight away when I'm not eating the way I intend to	□	□	□	□	□
28. I come up with excuses to eat tempting food	□	□	□	□	□
29. Tempting foods make me abandon my intention to eat healthily or control my weight.	□	□	□	□	□
30. If I see my weight has gone up at all, I take action straight away	□	□	□	□	□
31. I find it hard to keep track of my eating thoughout the day	□	□	□	□	□

5. Were any of these questions difficult for you to answer?

Question number(s): ______

6. What is your current weight approximately? Please give this in stones or kilograms.

Kilograms ______

Or Stones ______

Pounds ______

7. What is your height approximately? Please give this in feet and inches or centimetres.

Centimetres ______

Or Feet ______

Inches ______

8. Are you

Male ☐
Female ☐

9. How old are you?

10. If you wish to enter a draw to win a £25 M&S voucher, please provide your email address (optional). Email addresses will not be passed on or used for any other purpose, and will be deleted after the prize draw winner has been contacted. They will not be linked to your survey responses.

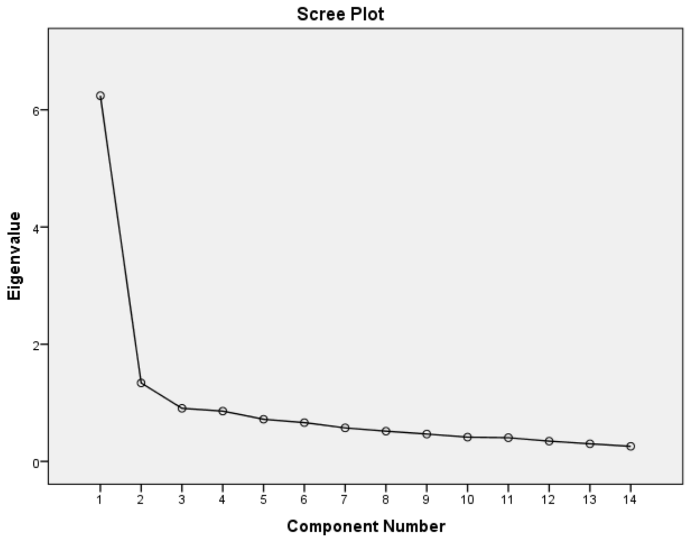
Email address (optional)

Repeat your email address (optional)

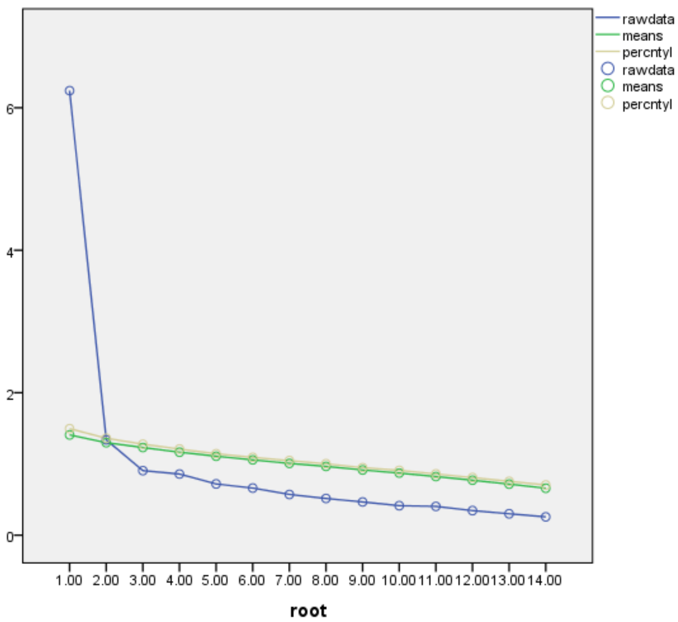
Thank you very much for taking part in this survey! Please, click ‘done’ to exit.

Appendix 4.7 Scree plot and Parallel analyses of the 14 items retained in the 'Internal Reliability and Factor Structure Study'

a) Scree Plot

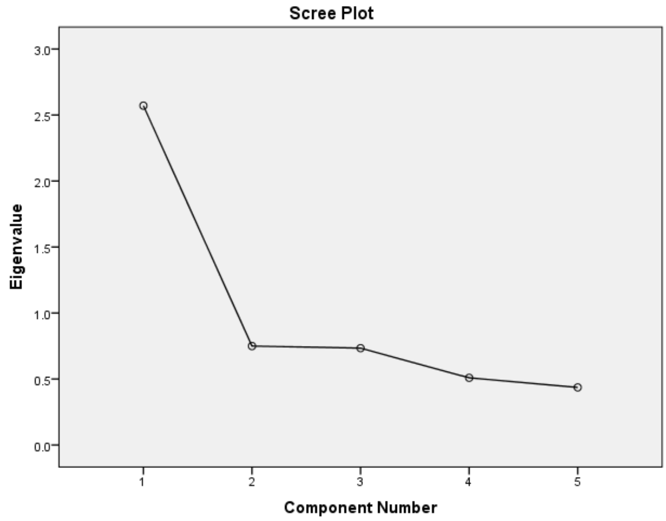


b) Parallel Analyses

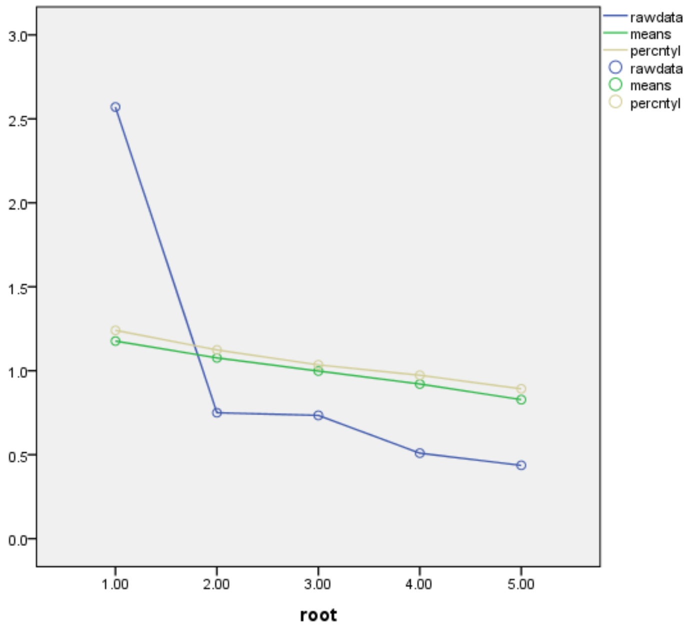


Appendix 4.8 Scree plot and Parallel analyses of the final 5 items retained in the 'Internal Reliability and Factor Structure Study'

a) Scree Plot



b) Parallel Analyses



Appendix 4.9 Ethical approval for the Reliability and Validity Study of the SREBQ

UCL RESEARCH ETHICS COMMITTEE
ACADEMIC SERVICES

UCL

Professor Jane Wardle
HBRC
Department of Epidemiology and Public Health
UCL

23 October 2014

Dear Professor Wardle

Notification of Ethical Approval
Project ID 5766/002: Development and validation of the self-regulation of eating behaviour questionnaire

In my capacity as Chair of the UCL Research Ethics Committee (REC) I am pleased to confirm that I have approved your study for the duration of the project i.e. **until December 2015.**

Approval is subject to the following conditions:

1. You must seek Chair's approval for proposed amendments to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form': http://ethics.grad.ucl.ac.uk/responsibilities.php

2. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported.

   Reporting Non-Serious Adverse Events
   For non-serious adverse events you will need to inform Helen Dougal, Ethics Committee Administrator (ethics@ucl.ac.uk), within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

   Reporting Serious Adverse Events
   The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.

On completion of the research you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research.

With best wishes for the research.

Yours sincerely

[redacted]

Professor John Foreman
Chair of the UCL Research Ethics Committee

Cc:
Nathalie Kliemann, Claudia Hunot, Fiona Johnson & Helen Croker, Applicant
Professor Andrew Steptoe

Appendix 4.10 Survey of the Reliability and Validity Study

Thank you for your interest in our research.

The aim of this research is to design a questionnaire to assess 'self-regulation of eating behaviour' (how easy people find it to control and manage their eating). In total the survey should only take 25 minutes of your time.

All responses to this questionnaire are confidential and your responses will not be linked to any identifying information.

This study has been approved by the UCL Research Ethics Committee [5766/002].

If you are happy to take part, please click on 'Next' below. By clicking on "Next" you are agreeing that:
- You have read the notes written above and you understand what the survey involves.
- You understand that as your participation is anonymous it will not be possible for us to withdraw your responses once you have completed the survey.

1. Do you find any of these foods tempting (that is, do you want to eat more of them than you think you should)? (Tick those which apply)

☐	Chocolate
☐	Crisps
☐	Cakes
☐	Ice cream
☐	Bread/toast
☐	Fizzy drinks
☐	Biscuits
☐	Sweets
☐	Popcorn
☐	Pastries
☐	Pizza
☐	Fried foods
☐	Chips
☐	Other foods
☐	I don't find any food tempting

If you have ticked other foods, please specify:

2. Do you intend NOT to eat too much of these foods you find tempting in the previous question?

Yes ☐

No ☐

3. Do you intend to have a healthy diet?

Yes ☐

No ☐

4. Please read the following statements and tick the boxes most appropriate to you.
For the next few questions, please, understand that:
- 'Tempting foods' are any food you want to eat more of than you think your should.
- 'Eating intentions' refer to the way you are aiming to eat, for example you may intend to avoid tempting foods or eat healthy foods.

		Never	Rarely	Sometimes	Often	Always
1	I'm good at resisting tempting food	□	□	□	□	□
2	I give up too easily on my eating intentions	□	□	□	□	□
3	I easily get distracted from my eating intentions	□	□	□	□	□
4	I find it hard to remember what I have eaten throughout the day	□	□	□	□	□
5	If I am not eating in the way I intend to I make changes	□	□	□	□	□

5. The reason I would eat a healthy is…

		1 (not at all true)	2	3	4	5 (very true)
1	Because I feel that I want to take responsibility for my own health	□	□	□	□	□
2	Because I personally believe it is the best thing for my health	□	□	□	□	□
3	Because it is very important for being as healthy as possible	□	□	□	□	□

6. How much do you agree with the following items?

		Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	Avoiding tempting foods (controlling my eating) is something I do frequently	□	□	□	□	□
2	Avoiding tempting foods (controlling my eating) is something I do automatically	□	□	□	□	□
3	Avoiding tempting foods (controlling my eating) is something I do without having to consciously remember	□	□	□	□	□
4	Avoiding tempting foods (controlling my eating) is something that makes me feel weird if I do not do it	□	□	□	□	□
5	Avoiding tempting foods (controlling my eating) is something I do without thinking	□	□	□	□	□
6	Avoiding tempting foods (controlling my eating) is something that would require effort not to do it	□	□	□	□	□
7	Avoiding tempting foods (controlling my eating) is something that belongs to my daily routine	□	□	□	□	□
8	Avoiding tempting foods (controlling my eating) is something I start doing before I realize I'm doing it	□	□	□	□	□
9	Avoiding tempting foods (controlling my eating) is something I would find hard not to do	□	□	□	□	□
10	Avoiding tempting foods (controlling my eating) is something I have no need to think about doing	□	□	□	□	□
11	Avoiding tempting foods (controlling my eating) is something that's typically "me"	□	□	□	□	□
12	Avoiding tempting foods (controlling my eating) is something I have been doing for a long time	□	□	□	□	□

7. How frequently do you typically eat the following types of food and drink?

		Less than once a week	1 a week	2-3 times a week	4-6 times a week	1 a day	2 a day	3 or more a day
1	Fruits	□	□	□	□	□	□	□
2	Vegetables	□	□	□	□	□	□	□
3	Sweet and salty snacks	□	□	□	□	□	□	□
4	Sugary drinks	□	□	□	□	□	□	□

8. How successful are you in watching your weight?

1 (not successful) ☐
2 ☐
3 ☐
4 ☐
5 ☐
6 ☐

7 (very successful) ☐
Not applicable ☐

9. How successful are you in losing extra weight?
1 (not successful) ☐
2 ☐
3 ☐
4 ☐
5 ☐
6 ☐
7 (very successful) ☐
Not applicable ☐

10. How difficult do you find it to stay in shape?
1 (not difficult) ☐
2 ☐
3 ☐
4 ☐
5 ☐
6 ☐
7 (very difficult) ☐
Not applicable ☐

11. How healthy is your diet?
1 (not healthy) ☐
2 ☐
3 ☐
4 ☐
5 ☐
6 ☐
7 (very healthy) ☐

12. Thinking about all parts of your life how well do the following statements describe you?

		1 (not at all)	**2**	**3**	**4**	**5 (very much)**
1	I am good at resisting temptation	☐	☐	☐	☐	☐
2	I have a hard time breaking bad habits	☐	☐	☐	☐	☐
3	I am lazy	☐	☐	☐	☐	☐
4	I say inappropriate things	☐	☐	☐	☐	☐
5	I do certain things that are bad for me, if they are fun	☐	☐	☐	☐	☐
6	I refuse things that are bad for me	☐	☐	☐	☐	☐
7	I wish I had more self-discipline	☐	☐	☐	☐	☐
8	People would say I have iron self-discipline	☐	☐	☐	☐	☐
9	Pleasure and fun sometimes keep me from getting work done	☐	☐	☐	☐	☐
10	I have trouble concentrating	☐	☐	☐	☐	☐
11	I am able to work effectively toward long-term goals	☐	☐	☐	☐	☐
12	Sometimes I can't stop myself from doing something, even if I know it is wrong	☐	☐	☐	☐	☐
13	I often act without thinking through all the alternatives	☐	☐	☐	☐	☐

13. In general, would you say your health is…
Poor ☐
Fair ☐
Good ☐
Very good ☐
Excellent ☐

14. What is your current weight approximately? Please give this in stones or kilograms.
Kilograms [ ]

Or Stones

Pounds

15. What is your height approximately? Please give this in feet and inches or centimetres.

Centimetres

Or Feet

Inches

16. Are you

Male ☐

Female ☐

19. How old are you?

17. Are you…

Single ☐

Married ☐

Living as married ☐

Separated ☐

Divorced ☐

Widowed ☐

18. How is the first part of your postcode?

19. What best describes your ethnic origin?

White ☐

Black ☐

Asian ☐

Mixed ☐

Other ☐

20. What is the highest level of education you have completed or are doing now?

Primary school ☐

Secondary school ☐

O level/ GCSEs ☐

A levels ☐

Technical or trade certificate ☐

Diploma ☐

Degree ☐

Post-graduate degree ☐

21. What is your current employment situation? (tick one that currently takes most of your time)

Employed full-time ☐

Employed part-time ☐

Unemployed ☐

Self-employed ☐

Full-time homemaker ☐

Unpaid/ Voluntary work ☐
Student ☐
Disable or too ill to work ☐
Retired ☐

22. Please select the option which best describes your current living arrangement (main residence)

Own your home outright ☐
Own your home with mortgage ☐
Rent from local authority/ housing association ☐
Rent privately ☐
Living with parents ☐
Living in University/ College halls ☐

Thank you very much for taking part in this survey!

Please, click ‘done’ to exit.

Appendix 5.1 List of universities members of the Universities UK in London

Region	Members of the Universities UK in London[a]	Included	Departments/Schools	
			Contacted (N)	**Accepted* (N)**
North East London	London Metropolitan University	Yes	6	1
North West London	Middlesex University	Yes	8	1
West London	Brunel University London	Yes	9	1
Central London	Birkbeck, University of London	Yes	9	3
	City University London	Yes	23	1
	Guildhall School of Music and Drama	No	-	-
	Heythrop College	No	-	-
	Imperial College London	Yes	11	2
	King's College London	No	-	-
	London Business School	No	-	-
	London South Bank University	No	-	-
	Regent’s University London	No	-	-
	Royal College of Art	No	-	-
	Royal College of Music, London	No	-	-
	SOAS, University of London	Yes	3	1
	The London School of Economics and Political Science	No	-	-
	The Royal Central School of Speech & Drama	No	-	-
	University College London	Yes	40	15
	University of the arts London	No	-	-
	Westminster University	Yes	6	3
East London	Queen Mary University of London	No	-	-
	University of East London	Yes	9	2
South East London	Goldsmiths, University of London	Yes	7	2
	University of Greenwich	Yes	4	2
South West London	St George's, University of London	No	-	-
	University of Roehampton	Yes	9	1

[a]Data from ("Universities UK," 2015). *Number of Departments or Schools that accepted to forward the recruitment email to their first year undergraduate students

Appendix 5.2 Survey of the online longitudinal study with first year undergraduate students

Thank you for your interest in our research.

This study has been approved by the UCL Research Ethics Committee [5766/003].

The aim of this research is to explore the different ways in which people manage what they eat.

In total the survey should only take 5 minutes of your time.

If you take part in the research your answers will remain confidential and it will not be possible to identify you from them. It is really important that your responses are honest and as accurate as possible.

You should only participate if you want to; choosing not to take part will not disadvantage you in any way and will not affect your academic progress. If you do decide to take part you are still free to withdraw at any time and without giving a reason.

We would be very grateful for your contribution to this research.

If you are happy to take part, please click on 'Next' below. By clicking on "Next" you are agreeing that:

- You have read the notes written above and you understand what the survey involves.
- You understand that as your participation is anonymous it will not be possible for us to withdraw your responses once you have completed the survey.

If you would like more information about the study please e-mail the UCL Researcher, Nathalie Kliemann, at ucl.selfregulation@gmail.com

1. Do you find any of these foods tempting (that is, do you want to eat more of them than you think you should)? (Tick those which apply)

☐	Chocolate
☐	Crisps
☐	Cakes
☐	Ice cream
☐	Bread/toast
☐	Fizzy drinks
☐	Biscuits
☐	Sweets
☐	Popcorn
☐	Pastries
☐	Pizza
☐	Fried foods
☐	Chips
☐	Other foods
☐	I don't find any food tempting

If you have ticked other foods, please specify:

2. Do you intend NOT to eat too much of these foods you find tempting in the previous question?

Yes ☐

No ☐

3. Do you intend to have a healthy diet?

Yes ☐

No ☐

4. Please read the following statements and tick the boxes most appropriate to you.

For the next few questions, please, understand that:

- 'Tempting foods' are any food you want to eat more of than you think your should.

- ‘Eating intentions’ refer to the way you are aiming to eat, for example you may intend to avoid tempting foods or eat healthy foods.

		Never	Rarely	Sometimes	Often	Always
1	When I decide to change the way I eat I get started straight away	□	□	□	□	□
2	Situations come up which stop me eating the way I intend to	□	□	□	□	□
3	I'm good at resisting tempting food	□	□	□	□	□
4	I stick to my eating intentions even when I am feeling upset or stressed	□	□	□	□	□
5	I stay focused on my eating intentions even when it's difficult	□	□	□	□	□
6	I easily get distracted from the way I intend to eat	□	□	□	□	□
7	Thinking about my eating intentions helps me resist tempting food	□	□	□	□	□
8	When there is tempting food around I eat it even if I am not hungry	□	□	□	□	□
9	I manage to stick to my eating intentions	□	□	□	□	□
10	When I am in front of tempting food I forget about the way I intend to eat	□	□	□	□	□
11	I find it hard to remember what I have eaten throughout the day	□	□	□	□	□
12	I have trouble making myself choose healthy food in tempting situations	□	□	□	□	□
13	It is difficult for me to break bad eating habits[1]	□	□	□	□	□
14	I refuse tempting food even if it is delicious	□	□	□	□	□
15	People would say that I have strong self-discipline when it comes to food[2]	□	□	□	□	□
16	I eat tempting food without meaning to	□	□	□	□	□
17	I eat things that taste good at the time, the regret it later on	□	□	□	□	□
18	I keep track of what I eat even when I am feeling stressed or upset	□	□	□	□	□
19	If I am not eating the way I intend to I make changes	□	□	□	□	□
20	I find it hard to control my eating	□	□	□	□	□
21	I give up too easily on my eating intentions	□	□	□	□	□
22	Tempting foods make me abandon my eating intentions	□	□	□	□	□
23	I come up with excuses to eat tempting food	□	□	□	□	□
24	If I notice something wrong with the way I am eating, I find a way to solve it	□	□	□	□	□

5. How frequently do you typically eat the following types of food and drink?

		Less than once a week	1 a week	2-3 times a week	4-6 times a week	1 a day	2 a day	3 or more a day
1	Fruits	□	□	□	□	□	□	□
2	Vegetables	□	□	□	□	□	□	□
3	Sweet and salty snacks	□	□	□	□	□	□	□
4	Sugary drinks	□	□	□	□	□	□	□
5	Alcoholic drinks	□	□	□	□	□	□	□

6. What is your current weight approximately? Please give this in stones or kilograms.

Kilograms (e.g. 58 kg)

Or Stones and Pounds

(e.g. 9 st and 2 Ib)

Or just pounds (e.g. 128 Ib)

7. What is your height approximately? Please give this in feet and inches or centimetres.

Centimetres (e.g. 58 kg)

Or Feet and Inches

(e.g. 5 ft and 4 in)

Or just inches (e.g. 64 in)

8. How often do you weigh yourself?
Every day ☐
About once a week ☐
About once a month ☐
Rarely ☐
Never ☐

9. When was the last time you weighed yourself?
Today or yesterday ☐
About a week ago ☐
About a month ago ☐
A few months ago ☐
More than a year ago ☐

10. What university are you studying at? Please enter the name of your university in the box below.

11. Are you
A first year undergraduate student ☐
A second year undergraduate student ☐
A third year undergraduate student ☐
A fourth year undergraduate student ☐
A postgraduate student ☐

12. Are you
Male ☐
Female ☐

13. How old are you?

14. What best describes your ethnic origin?
White ☐
Black ☐
Asian ☐
Mixed ☐
Other ☐

15. Please select the option which best describes your current living arrangement (main residence)
Living in University/ College halls ☐
Living with parents ☐
Rent privately ☐
Rent from local authority/ housing association ☐
Own your home ☐

16. We would like to ask you to take part in the same survey again in a couple of months' time. You can enter a draw to win two £20 high street vouchers if you decide to take part a second time. If you are willing to be contacted again, please enter your email address twice in the boxes below to confirm. We assure you that email addresses will not be passed on and will not be linked to your survey responses.

Email address (optional)

Repeat your email address (optional)

Thank you very much for taking part in this survey! Please, click 'done' to exit.

Appendix 5.3 Ethical approval for the study with first year undergraduate students (Study 2) and Top Tips App study (Study 4)

UCL RESEARCH ETHICS COMMITTEE
ACADEMIC SERVICES

8 July 2015

Professor Jane Wardle
HBRC
Department of Epidemiology and Public Health
UCL

Dear Professor Wardle

Notification of Ethical Approval
Project ID: 5766/003: Enhancing self-regulation of eating behaviour and its relationship to weight and healthy diet in adults

I am pleased to confirm in my capacity as Chair of the UCL Research Ethics Committee (REC) that your study has been approved by the REC for the duration of the project, until September 2016.

Approval is subject to the following conditions:

1. You must seek Chair's approval for proposed amendments to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form':

2. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported.

   Reporting Non-Serious Adverse Events
   For non-serious adverse events you will need to inform Helen Dougal, Ethics Committee Administrator (ethics@ucl.ac.uk), within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

   Reporting Serious Adverse Events
   The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.

On completion of the research you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research.

With best wishes for the research.

Yours sincerely

[redacted]

Professor John Foreman
Chair of the UCL Research Ethics Committee

Cc:
Nathalie Kliemann et al, Applicants
Professor Andrew Steptoe

Appendix 5.4 Pearson correlation between weight outcomes, dietary outcomes and potential covariates

Baseline data	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1 Weight changes												
2 5% weight gain[a]	**.73***											
3 High F&V intake[b]	-.03	-.03										
4 Low SSS intake[c]	-.03	-.09	.04									
5 Low SD intake[d]	.03	.01	**.19***	**.17***								
6 Age	-.09	-.14	-.05	-.01	.01							
7 Gender[e]	.00	.01	**.19***	-.02	**.14**	-.02						
8 Ethnic origin[f]	-.02	-.02	-.12	-.04	-.06	-.01	-.05					
9 College halls[g]	.04	.04	.16	.05	-.01	**-.19***	-.03	-.08				
10 Living with parents[h]	-.07	.02	-.09	.05	**.17***	-.02	.02	**.16***	**-.59***			
11 Renting/own home[i]	.01	-.07	-.11	-.09	-.14	**.25***	.02	-.04	**-.69***	**-.17***		
12 High AD intake[j]	.08	.11	-.05	.05	.15	.08	.08	**.24***	**-.18***	**.25***	.01	

Note= [a]Gained at least 5% of their initial body weight (No=0 and Yes=1). [b]Maintained or achieved high Fruit and vegetables intake (No=0 and Yes=1). [c]Maintained or achieved low Sweet and salty snacks intake (No=0 and Yes=1). [d]Maintained or achieved low Sugary drinks intake (No=0 and Yes=1). [e]Gender, Male=0 and Female=1. [f]Ethnicity, White=0 and Other=1. [g]College/University halls, No=0 and Yes=1. [h]Living with parents, No=0 and Yes=1. [i]Renting or owing their home, No=0 and Yes=1. [J]Maintained or achieved low alcoholic drinks intake (No=0 and Yes=1). 2-tailed *p*-value. *p<.01

Appendix 6.1 Paper published in IJBNPA

Kliemann *et al. International Journal of Behavioral Nutrition and Physical Activity* (2017) 14:119
DOI 10.1186/s12966-017-0578-8

International Journal of Behavioral Nutrition and Physical Activity

RESEARCH Open Access

The role of self-regulatory skills and automaticity on the effectiveness of a brief weight loss habit-based intervention: secondary analysis of the 10 top tips randomised trial

Nathalie Kliemann[1], Victoria Vickerstaff[2], Helen Croker[1], Fiona Johnson[1], Irwin Nazareth[2] and Rebecca J. Beeken[1,3*]

Abstract

Background: Habit-interventions are designed to promote the automaticity of healthy behaviours and may also enhance self-regulatory skills during the habit-formation process. A recent trial of habit-based advice for weight loss (10 Top Tips; 10TT), found that patients allocated to 10TT lost significantly more weight over 3 months than those allocated to usual care, and reported greater increases in automaticity for the target behaviours. The current study aimed to test the hypothesis that i) 10TT increased self-regulatory skills more than usual care, and ii) that self-regulatory skills and automaticity changes mediated the effect of 10TT on weight loss.

Methods: 537 obese patients from 14 primary care practices in the UK were randomized to receive 10TT or usual care. Patients in the 10TT group received a leaflet containing tips for weight loss and healthy habits formation, a self-monitoring log book and a wallet-sized shopping guide on how to read food labels. Patients were weighed and completed validated questionnaires for self-regulation and automaticity at baseline and 3-month follow-up. Within-group and Between-group effects were explored using Paired T-test and ANCOVA, respectively. Mediation was assessed using bootstrapping to estimate indirect effects and the sobel test.

Results: Over 3 months patients who were given 10TT reported greater increases in self-regulatory skills (Mean difference: .08; 95% CI .01; .15) than those who received usual care. Changes in self-regulatory skills and automaticity over 3 months mediated the effect of the intervention on weight loss (β = .52, 95% Bias Corrected CI .17; .91).

Conclusions: As hypothesised, 10TT enhanced self-regulatory skills and changes in self-regulatory skills and automaticity mediated the effect of the intervention on weight loss. This supports the proposition that self-regulatory training and habit formation are important features of weight loss interventions.

Trial registration: This study was prospectively registered with the International Standard Randomised Controlled Trials (ISRCTN16347068) on 26 September 2011.

Keywords: Self-regulation, Habit formation, Automaticity, Weight loss, Intervention

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Full list of author information is available at the end of the article

Appendix 6.2 CONSORT checklist

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	Not applicable
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	Not applicable
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	Pages 168-70
	2b	Specific objectives or hypotheses	Page 170
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	Page 171
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	Not applicable
Participants	4a	Eligibility criteria for participants	Page 171
	4b	Settings and locations where the data were collected	Page 171
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	Page 172-74
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	Page 175-80
	6b	Any changes to trial outcomes after the trial commenced, with reasons	Not applicable
Sample size	7a	How sample size was determined	Page 172
	7b	When applicable, explanation of any interim analyses and stopping guidelines	Not applicable

Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	Page 172
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	Page 172
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	Page 172
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	Page 172
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and howN	Page 175
	11b	If relevant, description of the similarity of interventions	No applicable
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	Page 180-83
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	Page 180-83
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	Page 184-86
	13b	For each group, losses and exclusions after randomisation, together with reasons	Page 185
Recruitment	14a	Dates defining the periods of recruitment and follow-up	Page 171
	14b	Why the trial ended or was stopped	Not applicable
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Page 186
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	Page 180 & 184-86
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	Page 189-96
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	Not applicable
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	Page 189-86
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	Not applicable

Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	Page 205-07
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	Page 205-07
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	Page 202-05
Other information			
Registration	23	Registration number and name of trial registry	Page 171
Protocol	24	Where the full trial protocol can be accessed, if available	Page 171
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	Page 171

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

Appendix 6.3 Recruitment letter and information sheet

Dear ___,

My name is (insert) and I am a researcher at your GP surgery. I would like to invite you to participate in a research study looking at a simple weight-loss intervention; the 10 Top Tips trial. This study is funded by the Medical Research Council and involves researchers from University College London.

I have enclosed an information sheet with more details on what you will be asked to do if you decide to participate in this study. Taking part in the study is your decision. If you have any questions about the study, Dr Rebecca Beeken is happy to answer any questions. You can contact her on 02076 791 632 or e-mail: r.beeken@ucl.ac.uk

Please complete the form at the bottom of this letter, telling us whether you would like to take part or not. Tear off the form and return it in the stamped addressed envelope provided. If you do express an interest in taking part, I will be in touch to arrange your first appointment. If you are not interested in taking part, then this will not affect your care at the practice in any way.

Thank you for your consideration. We look forward to hearing from you.

With kind regards,
(Signature)
(Name)

Name: (insert patient name)
Please tick the appropriate box:
I am interested in taking part in the 10 Top Tips Trial. ☐
I am not interested in taking part in the 10 Top Tips Trial ☐

DEPARTMENT OF EPIDEMIOLOGY & PUBLIC HEALTH
HEALTH BEHAVIOUR RESEARCH CENTRE

UCL

Patient information sheet
10 Top Tips Trial

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. If there is anything that is not clear or you would like more information, please telephone the Trial Manager (Dr Rebecca Beeken (020 7679 1691). Take time to decide whether or not you wish to take part.

What is the purpose of this study?
This study is concerned with promoting healthy eating and activity habits to help with weight loss. We are interested in whether a leaflet describing behaviours known to be associated with weight control, along with strategies to make them habitual/automatic ('10 Top Tips') will lead to more weight loss compared with usual care. We hope that this will enable us to improve care for patients who would like help from their GP in managing their weight.

Why have I been invited?
You have been invited because the GP records show that weight loss would be beneficial to your health.

Do I have to take part in the study?
No. You do not have to take part in this study. If you decide not to take part your health care will not be affected in any way. Your participation is voluntary and you may choose to withdraw from the study at any time.

What will be involved if I agree to take part in this study?
The study will run for 24 months in total. If you choose to participate you will be allocated to one of two groups. One will receive the 10 Top Tips leaflet, the other will not. This will help us to see if the 10 Top Tips leaflet makes a difference compared with usual care. To try to make sure the groups are the same to start with, each patient is put into a group by chance (randomly). Only you and the practice nurse will know which group you are in. The researchers will not know whether you have received the leaflet or not.

> If you are in the first group, you will meet the practice nurse for baseline measurements of weight and height, waist circumference, blood pressure and a small blood sample will be taken (5-10ml, equivalent to 1-2 teaspoons). We will also ask you to complete a questionnaire asking about your eating habits, activity levels, and quality of life. You will then be given the 10 Top Tips leaflet with additional brief information on forming healthy habits. This appointment may take up 1hour and 30minutes. Over the next two years, the nurse will arrange to meet with you to measure your weight and waist circumference five times, and on each occasion you will also complete a brief questionnaire. Each appointment will last between 30minutes-1 hour. At the second appointment only, 3 months after your first assessment, you will be seen by a different nurse. She will not know if you received the leaflet or not. You will have a second blood test and blood pressure measurement with this nurse. You will also be given simple diary sheets to record whether you have been able to stick to the tips for the first 3 months, and you will be asked to return completed sheets to the researchers. You may also be invited to take part in a recorded telephone interview with a researcher from UCL.

describing your experience of the 10 Top Tips; things you have liked and things you've found difficult.

If you are allocated to the second group, you will meet the practice nurse for baseline measurements of weight and height, waist circumference, blood pressure and a small blood sample (5-10ml, equivalent to 1-2 teaspoons), but you will not be given the leaflet. This appointment may take up 1hour and 30minutes. Over the next two years, the nurse will arrange to meet with you to measure your weight and waist circumference five times, and on each occasion you will also complete a brief questionnaire. Each appointment will last between 30minutes-1 hour. At the second appointment only, 3 months after your first assessment, you will be seen by a different nurse. She will not know if you received the leaflet or not. You will have a second blood test and blood pressure measurement with this nurse. If the study results suggest the leaflet is effective, you will be offered it in the future.

Taking part in the study, in either group, does not prevent you from using other methods of weight control, should you wish to do so.

Who is involved in this study?
Researchers at University College London are carrying out this study.

What other information will be collected in the study?
The practice nurse will take some information from your medical records, including how often you use the health services, any chronic illnesses you have, and any medications you are on. This information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998. The researchers will not have access to your medical records. If for any reason you are unable to continue to take part in the study, the research team would keep any data collected and continue to use it confidentially.

Will there be any effects on my health care?
No. Your participation in this study will not affect the care you will receive.

Will the information obtained in the study be confidential?
Yes, your participation in this study will be kept confidential. All information you provide will be kept confidential in accordance with the 1998 Data Protection Act. No names or details of individual patients will be given in any reports or publications arising from this work.

Will anyone else be told about my participation in the study?
No. Only your GP, the practice nurse and the study researchers will know of your participation in this study.

Who can I contact for independent advice about participating in the study?
If you would like to seek independent advice about participating in the study, you may like to talk to your GP, who is not a member of the team doing this research and so can give you an impartial view. They will be able to answer any concerns you may have about taking part in the study.

What if I am harmed?
In the unlikely event that you are harmed by your participation in this study, there are special compensation arrangements. If you are harmed due to someone's negligence, then you may have grounds for legal action. If your participation in the study raises any concerns or issues for you, you should discuss these with your GP or hospital doctor.

What if I wish to complain about the way in which this study has been conducted?
If you have *any* cause to complain about *any* aspect of the way in which you have been treated during the course of this study, the Independent Complaints and Advocacy Service offers free advice on how to make a complaint about NHS treatment. Their contact number is 0845 1203734. You are not compromised in any way because you have taken part in a research study.

If you have any complaints or concerns, please contact Dr Rebecca Beeken by telephone (020 7679 1691) or email (r.beeken@ucl.ac.uk).

Appendix 6.4 The 10TT leaflet

reduce the risk
CANCER RESEARCH UK

ten top tips

weight loss tips based on scientific evidence

in partnership with WEIGHTCONCERN
FIGHTING OBESITY WITH KNOWLEDGE

ten top **tips**

This leaflet contains a programme of weight loss tips, all based on scientific evidence. They will help you take in fewer calories and burn more energy through activity. Ten Top Tips are simple habits that everyone can fit into their daily routines and doing all ten over the longer-term will help you lose weight and keep it off.

How can the Ten Top Tips help you control your weight?

The Ten Top Tips programme helps you incorporate lifestyle changes into your daily routine so that they become automatic and easy to maintain. To develop new healthy habits you need to:

- **Plan ahead:** In the first week or two, spend a little time working out in advance how you are going to do the tips. For example work out how to fit five servings of fruit and vegetables and the extra walking into your day.
- **Tracking your progress:** Use tick sheets each day to record if you do each of the tips. Keep this up until the tips have become automatic. Record-keeping increases success in developing healthy habits.

A tear off tick sheet can be found at the back of this leaflet.

Does being overweight matter?

Being overweight affects your health. It can increase the risk of several types of cancer. These include cancers of the bowel, kidney, oesophagus (foodpipe) and womb, as well as breast cancer in women who have been through the menopause. It can also increase the risk of diabetes, high blood pressure, coronary heart disease, osteoarthritis and stroke.

We all know how difficult it is to lose weight and keep it off. The good news is that if you are overweight losing just 5-10% of your body weight and keeping it off will have a positive effect on your health. For most people this will be around 3-10kg or $^1/_2$ - $1^1/_2$ stone.

(NB If you are seriously overweight and have other health problems, it may be advisable to seek advice from your Doctor before beginning a weight management programme).

Visit **www.reducetherisk.org.uk** for further information on all of these tips.

Keep to your meal routine

Try to eat at roughly the same times each day, whether this is two or five times a day.

Handy Hints:

- Pick a pattern that fits in with your own daily routine and stick to it.
- If you are someone who needs snacks, try to snack around the same time each day.
- Try planning when you intend to eat and check at the end of the day if you have achieved this.

2 Go reduced fat

Choose reduced fat versions of foods such as dairy products, spreads and salad dressings where you can. Use them sparingly as some can still be high in fat.

Handy Hint:

- Change to semi-skimmed milk and save 60 calories/day, amounting to 420 calories. over a week (based on consuming 300mls milk/day).

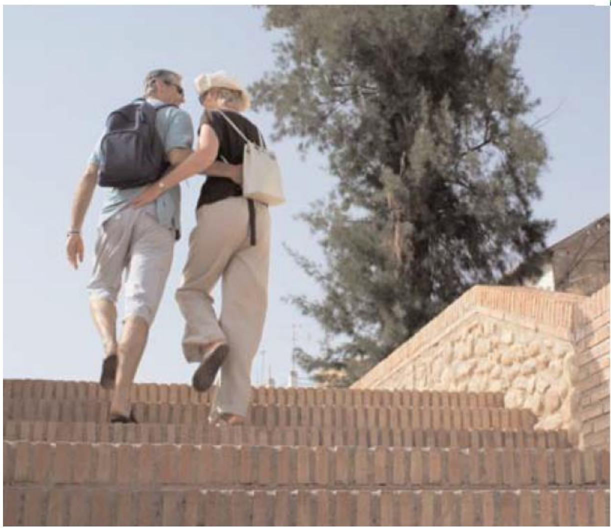
Keeping a record has been shown to increase people's success in developing **healthy habits**

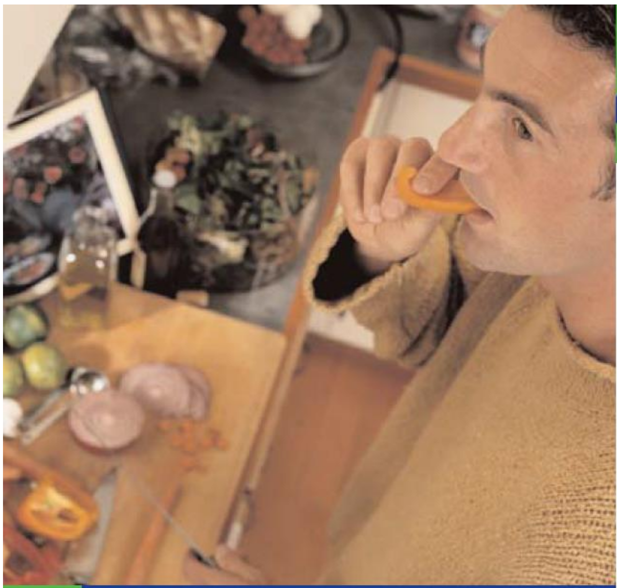
3 Walk off the weight

Walk 10,000 steps (equivalent to 60-90 minutes moderate activity) each day. You can use a pedometer to help count the steps. You can break up your walking throughout the day.

Handy Hints:

- 5000 steps a day extra (40mins walking at a brisk pace), will burn 1240 calories over a week.
- Take the stairs rather than the lift.





4 Pack a healthy snack

If you snack, choose a healthy option such as fresh fruit or low calorie yogurts instead of chocolate or crisps.

Handy Hints:

- Have a banana instead of a snack-size chocolate bar and save 225 calories.
- Take a piece of fruit to work in your bag so that you have it with you for a snack.
- Choose yogurts with less than 100 calories per pot. The calcium will also keep your bones healthy.

5 Look at the labels

Be careful about food claims. Check the fat and sugar content on food labels when shopping and preparing food.

Handy Hints:

- A low fat digestive biscuit has the same number of calories as the standard digestive biscuit at 70 calories. Check the fat and sugar content.
- Order our shopping guide from the Reduce the Risk website: www.reducetherisk.org.uk

Creating a **daily routine**, **keeping track of your progress** and **planning ahead** are key to developing healthier habits to last a lifetime.

6 Caution with your portions

Don't heap food on your plate (except vegetables). Think twice before having second helpings.

Handy Hint:

- Fill your plate up with lots of vegetables. They are low in calories and will help satisfy your hunger.

7 Up on your feet

Break up your sitting time. Stand up for ten minutes out of every hour.

Handy Hints:

- Standing up on the bus or train burns an extra 70 calories an hour.
- When watching TV try to stand up during the ad breaks and do a few chores (e.g wash the dishes or put the rubbish out).

8 Think about your drinks

Choose water or sugar-free squashes. Unsweetened fruit juice is high in natural sugar so limit it to 1 glass per day (200ml / $^1/_3$ pint). Alcohol is high in calories so try to limit the amount you drink.

Handy Hint:

- A pint of standard beer has 2 units of alcohol and 182 calories.

9 Focus on your food

Slow down. Don't eat on the go or while watching TV. Eat at a table if possible.

Handy Hints:

- Eating meals at the table will help you to focus on the amount of food you eat.
- Don't eat while walking, wait until you get there and take time to concentrate on what you are eating.

10 Don't forget your 5 a day

Eat at least 5 portions of fruit and vegetables a day (400g in total).

Handy Hints:

- A medium sized apple or banana or 3 serving spoonfuls of peas is 1 portion.
- Try having fruit or vegetables with every meal. This makes it easier to reach the five a day.

frequently asked **questions**

Should I choose 'diet' foods?

Low calorie foods can be useful for reducing your energy intake but be careful of misleading claims and check the labels. For example low fat biscuits and other sweet foods may be lower in fat but not in calories.

I don't eat any fruit and vegetables. Do I have to start eating five all at once?

It may work better for you to start eating a smaller number and build up over time. Make sure your plan is clear so you can judge if you achieve it or not each day.

Do I have to make all these changes at once?

The sooner you can build the tips into your life the quicker you'll start to lose weight. But it can be difficult to make all these changes at once. If you prefer you could try a smaller number until you feel confident enough to move on to others. The end goal is to fit all of the tips into your lifestyle.

The sooner you can **incorporate all the tips** into your life the quicker you'll start to lose weight.

Should I avoid occasional opportunities to exercise if not part of my normal routine?

It is fine to do more but keep doing your routines as well. This applies to all the tips.

What do I do on days when I am doing something different to my normal routine? for example: when I am away on business or at weekends.

You can develop different routines for the doing the tips during the week and at weekends. If you are away on a trip, do your best to stick to most of the tips and then get back to your normal routine as soon as you return.

What if I lose interest in the tips?

Changing habits of a lifetime is hard work but once the tips become part of your normal routine you will hardly notice doing them. Just like brushing your teeth.

ten top tips tick sheet: Keeping track of your progress

Fill in this tick sheet every day to record whether or not you managed each tip. Keeping a record has been shown to increase people's success in developing healthy habits. Keeping track of your weight is also very useful. Daily weighing has been shown to increase successful weight control. In the notes column you can write details of how you are achieving the tips, and anything that particularly helps you use them. This information will help you plan for the next week.

ten top tips	m	t	w	t	f	s	s	done on 5 days or more?	notes
1. Keep to your meal routine									
2. Go reduced fat									
3. Walk off the weight (No. of steps)									
4. Pack a healthy snack									
5. Learn the labels									
6. Caution with your portions									
7. Up on your feet									
8. Think about your drinks									
9. Focus on your food									
10. Don't forget your 5 a day									
Your weight									

What do you plan to do next week? (e.g. I will write a shopping list to remind myself to buy fruit)

Guide to shopping

The following information provides you with some simple advice for understanding food labels.

	per 100g	
	a lot	a little
Sugars	10g	2g
Fat	20g	3g
Saturated fat	5g	1g
Fibre	3g	0.5g
Salt	1.25g	0.25g
Sodium	0.5g	0.1g

Reproduced with permission from the Foods Standards Agency

Look for the following information on food labels to make healthy choices:

Snacks
Less than 3g fat
and less than 8g sugar per serving

Breakfast cereals
Less than 5g fat
and less than 10g sugar per 100g

Ready meals
Less than 10g fat
and less than 350kcal per portion

Pre-packed sandwiches
Less than 6g fat
and less than 280kcal per sandwich pack

further information

Visit www.reducetherisk.org.uk for further information about the Ten Top Tips and more about the healthy choices that could reduce your risk of cancer.

Visit Weight Concern's website www.weightconcern.org.uk for further information about obesity and weight loss.

For more about cancer visit Cancer Research UK's patient information website www.cancerhelp.org.uk.

About Cancer Research UK

Cancer Research UK is the leading charity dedicated to research on the causes, treatment and prevention of cancer. If you would like to support our work please call 020 7121 6699 or visit our website.

Cancer Research UK
PO Box 123
London
WC2A 3PX
020 7242 0200
www.cancerresearchuk.org

Reg charity no. 1089464 2006 Ref: rtr400

About Weight Concern

Weight Concern is a UK charity committed to researching and developing more effective treatments for obesity. We also train health professionals in techniques to help support people who want to control their weight.

Weight Concern
Brook House
2-16 Torrington Place
London
WC1E 7HN
enquiries@weightconcern.org.uk
www.weightconcern.org.uk

Appendix 6.5 Self-monitoring log book

ten top **tips**

Logbook

WEIGHTCONCERN

Forming healthy habits

Ten Top Tips is about forming healthy habits to help you lose weight and keep the weight off for good. This logbook makes it easier to keep on track and turn healthy tips into habits.

What is a habit?

A habit is something you do automatically without having to think about it, like tying your shoelaces or brushing your teeth.

Habits are formed when you do something over and over again in the same place or at the same time.

How do you make new healthy habits?

The ten top tips leaflet describes simple tips to help you eat more healthily and be more active.

If you follow the tips every day, and do them in the same place and at the same time, they will become automatic and easier to stick to. You might even find it hard not to do them.

Keeping track of your progress in this logbook will help you get started.

What do you need to do next?

1. Read the ten top tips leaflet.
2. Fill in the monitoring sheets in this booklet each week.
3. See the website **www.weightconcern.org.uk** for more information and advice about the ten top tips.

ten top tips tick sheet

Fill in this tick sheet every day to record whether or not you managed each tip. You should aim to do as many of the tips as you can every day. With time and practice it should become easier to do all ten tips. You can also keep track of your weight and record it here.

week

ten top tips	m	t	w	t	f	s	s	done on 5 days or more
1 Keep to your meal routine								
2 Go reduced fat								
3 Walk off the weight (number of steps)								
4 Pack a healthy snack								
5 Learn the labels								
6 Caution with your portions								
7 Up on your feet								
8 Think about your drinks								
9 Focus on your food								
10 Don't forget your five a day								
Your weight Daily weighing has been shown to increase successful weight control.								

notes and planning sheet

In the notes column you can write details of how you are achieving the tips and anything that particularly helps you use them. This information will help you to plan for next week.

ten top tips	notes
1 Keep to your meal routine	
2 Go reduced fat	
3 Walk off the weight (number of steps)	
4 Pack a healthy snack	
5 Learn the labels	
6 Caution with your portions	
7 Up on your feet	
8 Think about your drinks	
9 Focus on your food	
10 Don't forget your five a day	
What do you plan to do next week?	

Appendix 6.6 Wallet sized shopping guide on how to read food labels

CANCER RESEARCH UK

The following information provides you with some simple advice for understanding food labels.

	Sugars	Fat	Saturated Fat	Salt
What is **high** per 100 g	over 15g	over 20g	over 5g	over 1.5g
What is **medium** per 100 g	between 5g and 15g	between 3g and 20g	between 1.5g and 5g	between 0.3g and 1.5g
What is **low** per 100 g	5g and below	3g and below	1.5g and below	0.3g and below

Based on information supplied by the Food Standards Agency

in partnership with WEIGHTCONCERN FIGHTING OBESITY WITH KNOWLEDGE

Look for the following information on food labels to make healthy choices:

Snacks
Less than 3g fat
and less than 8g sugar per serving

Breakfast cereals
Less than 5g fat
and less than 10g sugar per 100g

Ready meals
Less than 10g fat
and less than 350kcal per portion

Pre-packed sandwiches
Less than 6g fat
and less than 280kcal per sandwich pack

www.cancerresearchuk.org
www.weightconcern.org.uk

Reg charity no. 1089464 2008 Ref: rtr500

Appendix 6.7 Survey of the 10TT trial

ten top tips

QUESTIONNAIRE

Please read the instructions carefully before attempting to answer the questions.

The questionnaire asks about your current eating and exercise behaviours, your thoughts about food and dieting and how you feel about yourself.

Please be honest in your responses. All answers you give will be strictly confidential and it will not be possible to identify your responses in any reports or publications.

Please make sure you answer all questions.

WEIGHTCONCERN
FIGHTING OBESITY WITH KNOWLEDGE

First of all, we would like you to indicate how often you did each of the behaviours below over the past two weeks and whether it is something you do automatically.

1a. In the past two weeks I ate my meals at roughly the same time every day

-2	-1	0	1	2
None of the time	Rarely	Some of the time	Most of the time	All of the time

1b. Eating my meals around the same time every day is something I do automatically

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

2a.In the past two weeks I chose reduced fat foods

-2	-1	0	1	2
None of the time	Rarely	Some of the time	Most of the time	All of the time

2b. Choosing reduced fat foods is something I do automatically

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

3a. In the past two weeks I used high fat foods only sparingly

-2	-1	0	1	2
None of the time	Rarely	Some of the time	Most of the time	All of the time

3b. Using high fat foods only sparingly is something I do automatically

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

4a. Over the past two weeks on average I have walked					
Less than 2500 steps a day (<15mins)	About 2500 steps a day (approx 15mins)	About 5000 steps a day (approx 30mins)	About 7500 steps a day (approx 45mins)	About 10000 steps a day (approx 1hr)	More than 10000 steps a day (>1hr)

4b. Walking 10 000 steps a day is something I do automatically						
-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

5a. In the past two weeks I chose healthy snacks rather than an unhealthy snack					
-2	-1	0	1	2	N/A
None of the time	Rarely	Some of the time	Most of the time	All of the time	I never eat snacks

5b. Choosing healthy rather than unhealthy snacks is something I do automatically						
-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

6a. In the past two weeks I read the labels when buying food					
-2	-1	0	1	2	N/A
None of the time	Rarely	Some of the time	Most of the time	All of the time	I never shop for food

6b. Reading the labels when buying food is something I do automatically						
-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

7a. In the past two weeks I read labels when preparing food

-2	-1	0	1	2	N/A
None of the time	Rarely	Some of the time	Most of the time	All of the time	I never prepare food

7b. Reading the labels when preparing food is something I do automatically

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

8a. In the past two weeks I avoided large portions (except of fruit and vegetables)

-2	-1	0	1	2
None of the time	Rarely	Some of the time	Most of the time	All of the time

8b. Avoiding large portions (except of fruit and vegetables) is something I do automatically

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

9a. In the past two weeks I avoided second helpings

-2	-1	0	1	2
None of the time	Rarely	Some of the time	Most of the time	All of the time

9b. Avoiding second helpings is something I do automatically

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

10a. In the past two weeks I stood up for at least ten minutes every hour (while awake)

-2	-1	0	1	2
None of the time	Rarely	Some of the time	Most of the time	All of the time

10b. Standing for at least ten minutes every hour is something I do automatically

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

11a. In the past two weeks I drank water or sugar-free drinks instead of other soft drinks					
-2	-1	0	1	2	N/A
None of the time	Rarely	Some of the time	Most of the time	All of the time	I don't drink soft drinks

11b. Drinking water and sugar-free drinks instead of other soft drinks is something I do automatically						
-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

12a. In the past two weeks on average I ate a portion of fruit and vegetables (one portion is 80g, e.g. one banana, two satsumas, 2 inches cucumber, 2 tablespoons frozen veg, etc).				
0 times a day	1-2 times a day	3-4 times a day	5 times a day	More than 5 times a day

12b. Eating at least five portions of fruit and vegetables a day is something I do automatically						
-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

13a. In the past two weeks I weighed myself on average					
Never	Less than once a week	1-2 times a week	3-4 times a week	5-6 times a week	Every day

13b. Weighing myself is something I do automatically						
-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

14a. In the past two weeks when I ate, I ate at a table					
-2	-1	0	1	2	N/A
None of the time	Rarely	Some of the time	Most of the time	All of the time	I don't have a table to eat at

14b. Eating at a table is something I do automatically.

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

15a. In the past two weeks when I ate, I ate in front of the TV (including snacks)

-2	-1	0	1	2	N/A
None of the time	Rarely	Some of the time	Most of the time	All of the time	I don't have a TV

15b. Eating in front of the TV is something I do automatically

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

16a. In the past two weeks on average I drank more than 2 units of alcohol a day

-2	-1	0	1	2	N/A
None of the time	Rarely	Some of the time	Most of the time	All of the time	I don't drink alcohol

16b. Drinking more than two units of alcohol a day is something I do automatically

-3	-2	-1	0	1	2	3
Disagree			Neither agree/disagree			Agree

17. Please write down any weight loss programmes you have been following over the past 3 months:

WHAT YOU EAT AT THE MOMENT

How many portions of fruit do you usually eat? Please include those eaten at meal times or as a snack. (Examples of a serving are one apple or banana, a large slice of melon, 2 plums or satsumas, a small bowl of grapes, 3 tablespoons of tinned fruit, or ½ tablespoon of dried fruit)

Less than 1 per week	1 per week	2-3 per week	4-6 per week	1 per day	2 per day	Three or more per day
☐	☐	☐	☐	☐	☐	☐

How many portions of vegetables do you usually eat? Please include those eaten at meal times or as snacks. (Examples of a serving are 2 heaped tablespoons of broccoli or carrots, 3 tablespoons of sweetcorn or peas, or a bowl of salad.) *Please do not include potatoes, sweet potatoes or plantains as a vegetable serving.*

Less than 1 per week	1 per week	2-3 per week	4-6 per week	1 per day	2 per day	Three or more per day
☐	☐	☐	☐	☐	☐	☐

About how much milk do you yourself use in a day, for example on cereal, in tea or coffee?

	None	Less than a quarter-pint	About a quarter-pint	About half a pint	1 pint or more
Whole or Channel Islands	☐	☐	☐	☐	☐
Semi skimmed	☐	☐	☐	☐	☐
Skimmed	☐	☐	☐	☐	☐

How often do you eat/drink the following?

	Never / Rarely	Once a week	2-3 times a week	4-6 times a week	Once a day	Twice a day	3 or more times a day
Chocolate and sweets	☐	☐	☐	☐	☐	☐	☐
Biscuits, cakes, buns, pastries, ice-cream	☐	☐	☐	☐	☐	☐	☐
Regular/non diet fizzy drinks (e.g. Coke, 7Up)	☐	☐	☐	☐	☐	☐	☐
Diet/reduced sugar/sugar free fizzy drinks (e.g. Diet Coke)	☐	☐	☐	☐	☐	☐	☐
Fruit juice (100% juice, unsweetened)	☐	☐	☐	☐	☐	☐	☐
Other regular/non-diet drinks (e.g. squash, fruit drinks)	☐	☐	☐	☐	☐	☐	☐
Milkshakes and hot chocolate	☐	☐	☐	☐	☐	☐	☐
Water	☐	☐	☐	☐	☐	☐	☐

How many times a week do you eat a serving of the following foods?	Less than once a week or never	Once or twice a week	3-5 times a week	6 or more times a week
Cheese (incl cream cheese, NOT cottage)	☐	☐	☐	☐
Beefburgers or sausages	☐	☐	☐	☐
Beef, pork, lamb (incl nuts for vegetarians)	☐	☐	☐	☐
Bacon, meat pies	☐	☐	☐	☐
Chicken or turkey	☐	☐	☐	☐
Fish (NOT fried)	☐	☐	☐	☐
ANY fried food, fried fish, chips, cooked breakfast, samosas	☐	☐	☐	☐
Cakes, pies, puddings, pastries	☐	☐	☐	☐
Biscuits, chocolate, crisps	☐	☐	☐	☐
Coconut milk/ coconut cream	☐	☐	☐	☐

About how many rounded teaspoons of margarine, butter, other spread, or oil do you usually use in a day (e.g. on bread, sandwiches, toast, potatoes, vegetables, and in cooking)?

	None	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
Butter, lard or margarine or reduced (not low) fat spread (such as Flora, sunflower spread, Clover, Utterly Butterly)	☐	☐	☐	☐	☐	☐	☐	☐
Low fat spread (e.g. Flora Light, Diet Clover)	☐	☐	☐	☐	☐	☐	☐	☐
Oil (sunflower, olive, palm, rapeseed)	☐	☐	☐	☐	☐	☐	☐	☐

Please answer the following questions by circling the response that best describes how you are in terms of food and your eating behaviours. If you STRONGLY DISAGREE, circle 1. If you DISAGREE circle 2. If you are UNCERTAIN or UNSURE circle 3. If you AGREE circle 4, and if you STRONGLY AGREE circle 5. There are no right or wrong answers. Work quickly and don't think too long about your answers.

	Strongly disagree	Disagree	Agree	Strongly agree
1 It's hard for me to notice when I've had enough food	1	2	3	4
2 If I make a resolution to change the way I eat, I pay a lot of attention to how I'm doing	1	2	3	4
3 I can stick to a weight loss plan that works well	1	2	3	4
4 I usually only have to make one mistake with my diet in order to learn from it	1	2	3	4
5 I know how I want to eat healthily	1	2	3	4
6 I have trouble making my mind up about what to do to lose weight	1	2	3	4
7 Often I don't notice what I'm eating until someone calls it to my attention	1	2	3	4
8 When I want to lose weight I can usually think of a number of changes I could make	1	2	3	4
9 I usually keep track of my progress towards my weight loss goals	1	2	3	4
10 When it comes to deciding about a change to the way I eat, I feel overwhelmed by the choices	1	2	3	4
11 As soon as I see a problem in the way I'm eating, I start looking for possible solutions	1	2	3	4
12 I usually think before I eat.	1	2	3	4
13 I learn from my dieting mistakes	1	2	3	4
14 If I wanted to change how I eat I am confident that I could do it	1	2	3	4
15 I have trouble making plans to help me reach my weight loss goals	1	2	3	4
16 Most of the time I don't pay attention to what I'm eating	1	2	3	4
17 I put off making decisions about my weight	1	2	3	4
18 I am able to resist tempting food	1	2	3	4
19 I'm able to accomplish weight loss goals I set for myself	1	2	3	4
20 I don't notice the effects of my eating behaviour until it's too late	1	2	3	4
21 I have trouble following through with weight loss plans once I've made up my mind to try and lose weight	1	2	3	4
22 I get easily distracted from my weight loss plans	1	2	3	4
23 I have personal standards about eating healthily, and try to live up to them	1	2	3	4
24 I tend to keep doing the same thing, even when it doesn't help me reach my weight loss goals	1	2	3	4
25 I have a lot of willpower when it comes to food	1	2	3	4
26 When I'm trying to change my weight, I pay attention to how I'm doing	1	2	3	4
27 I set weight loss goals for myself and keep track of my progress	1	2	3	4
28 I give up on weight loss plans quickly	1	2	3	4
29 Once I have a weight goal, I can usually plan how to reach it	1	2	3	4
30 I have a hard time setting weight loss goals for myself	1	2	3	4
31 I don't seem to learn from my dieting mistakes	1	2	3	4

Appendix 6.8 Baseline characteristics by completers and non-completers for target behaviours

Characteristics	Target behaviours: Completers (N=371)	Target behaviours: Non-completers (N=166)	Statistics
Age (in years)			
Mean (sd)	58.4 (11.8)	55.0 (14.2)	t(271.7)=2.682, *p*=**.004**
Gender			
Female, % (n)	65.0 (241)	67.5 (112)	$X^2(1)=.321$, *p*=.571
Ethnic group			
White, % (n)	94.6 (351)	94.5 (156)	$X^2(1)=.001$, *p*=.976
Other, % (n)	5.4 (20)	5.5 (9)	
Qualification			
Non-degree, % (n)	46.2 (168)	49.0 (77)	$X^2(2)=1.065$, *p*=.587
Degree, % (n)	33.2 (121)	28.7 (45)	
Other, % (n)	20.6 (75)	22.3 (35)	
Weight (in kg)			
Mean (sd)	100.6 (17.1)	101.5 (18.1)	t(534)=-.566, *p*=.572
BMI (in kg/m^2)			
Mean (sd)	36.2 (5.1)	36.6 (5.1)	t(534)=-.696, *p*=.487
Self-regulation			
Mean (sd)	2.4 (.3)	2.4 (.3)	t(511)=.139, *p*=.889
Target behaviours			
Mean (sd)	3.2 (.5)	3.1 (.5)	t(504)=1.543, *p*=.123
Fruit & Vegetables			
Mean (sd)	1.81 (1.0)	1.65 (1.1)	t(503)=1.590, *p*=.113
Sweets Snacks			
Mean (sd)	.40 (.44)	.46 (.52)	
Median (IQR)	.25 (.14; .57)	.35 (.14; .56)	Mann Whitney=.382
Sugary drinks			
Mean (sd)	1.89 (.78)	1.87 (.84)	t(469)=.195, *p*=.845
Fat intake			
Mean (sd)	43.9 (14.0)	43.1 (14.4)	t(496)=.589, *p*=.556

Appendix 6.9 Baseline characteristics by completers and non-completers for each of the dietary behaviours outcomes

	Fruit & vegetable intake		**Snacks intake**		**Sugary drinks intake**		**Fat intake**	
Characteristics	Completers (N=376)	Non-completers (N=161)	Completers (N=370)	Non-completers (N=167)	Completers (N=330)	Non-completers (N=207)	Completers (N=359)	Non-completers (N=178)
Age (in years)								
Mean (SD)	58.5 (11.9)	54.6 (14.4)**	58.2 (12.1)	55.4 (13.7)*	57.5 (12.0)	57.1 (13.7)	58.1 (12.0)	55.7 (13.8)
Gender								
Female, % (N)	66.5 (250)	64.0 (103)	65.1 (129)	67.1 (112)	66.7 (220)	64.3 (133)	66.3 (138)	64.6 (115)
Ethnic group								
White, % (N)	94.9 (357)	93.8 (150)	95.1 (352)	93.4 (155)	95.5 (315)	93.2(192)	96.1 (345)	91.5 (162)
Other, % (N)	5.1 (19)	6.3 (10)	4.9 (18)	6.6 (11)	4.5 (15)	6.8 (14)	3.9 (14)	8.5 (15)
Qualification								
Non-degree, % (N)	45.8 (168)	50.0 (77)	45.7 (165)	50.0 (80)	46.1 (149)	48.5 (96)	44.7 (157)	51.8 (88)
Degree, % (N)	33.5 (123)	27.9 (43)	33.2 (120)	28.7 (46)	35.3 (114)	26.3 (52)	35.3 (124)	24.7 (42)
Other, % (N)	20.7 (76)	22.1 (34)	21.1 (76)	21.3 (34)	18.6 (60)	25.3 (50)	19.9 (70)	23.5 (40)
Weight (in kg)								
Mean (sd)	100.1 (16.4)	102.8 (19.5)	100.6 (16.9)	101.6 (18.4)	100.7 (16.6)	101.2 (18.7)	100.1 (16.6)	102.6 (18.8)
BMI† (in kg/m^2)								
Mean (sd)	36.2 (4.9)	36.7 (5.5)	36.3 (5.1)	36.5 (5.1)	36.4 (5.2)	36.3 (5.0)	36.1 (5.0)	36.7 (5.2)
Median (IQR)	34.7(32.7;38.6)	35.1(32.5; 40.0)	34.7(32.2; 39.0)	35.1(32.6; 39.3)	34.9(32.5; 39.1)	34.8(32.6; 39.1)	34.7(32.4; 38.6)	35.2(32.7; 39.7)
Self-regulation								
Mean (sd)	2.4 (.3)	2.4 (.3)	2.4 (.3)	2.4 (.3)	2.4 (.3)	2.4 (.3)	2.4 (.3)	2.4 (.3)
TB								
Mean (sd)	3.2 (.5)	3.1 (.5)	3.2 (.5)	3.1 (.5)	3.2 (.5)	3.1 (.5)	3.2 (.5)	3.1 (.5)
F&V								
Mean (sd)	1.83 (1.0)	1.60 (1.1)	1.83 (1.0)	1.63 (1.1)	1.83 (1.0)	1.65 (1.1)*	1.85 (1.0)	1.57 (1.0)*
SS								
Mean (sd)	.40 (.44)	.46 (.54)	.40 (.44)	.47 (.54)	.41 (.4)	.43 (.4)	.40 (.45)	.44 (.51)
Median (IQR)	.25 (.10; .57)	.35 (.14; .57)	.25 (.07; .57)	.35 (.14; .55)	.25 (.14; .57)	.25 (.14; .57)	.25 (.07; .57)	.25 (.14; .53)
SD								
Mean (sd)	1.88 (.78)	1.88 (.84)	1.87 (.78)	1.90 (.83)	1.87 (.78)	1.90 (.82)	1.88 (.77)	1.89 (.85)
Fat intake								
Mean (sd)	43.5 (13.78)	44.4 (15.0)	43.7 (13.9)	43.6 (14.6)	46.9 (14.7)	45.4 (16.3)	43.8 (13.7)	43.4 (15.0)

Note= ***p*≤.001. **p*≤.01

Appendix 6.10 Baseline differences between those who sent back the log book and those who did not

Characteristics	Returned the logbook		Statistic
	Yes (N=83)	Not (N=454)	
Age in years			
Mean (sd)	61.8 (10.7)	56.5 (12.9)	t(129.6)=4.018, *p*<.**001**
Gender			
Female, % (N)	69.9 (58)	65.0 (295)	$\chi^2(1)=.748$, *p*=.387
Ethnic group			
White[a], % (N)	96.4 (80)	94.3 (427)	Fisher's Exact
Other[b], % (N)	3.6 (3)	5.7 (26)	Test=.316
Qualification[1]			
Non-degree[c], % (N)	45.1 (37)	47.4 (208)	$\chi^2(2)=.628$, *p*=.731
Degree[d], % (N)	30.5 (25)	32.1 (141)	
Other[e], % (N)	24.4 (20)	20.5 (90)	
Weight in kg			
Mean (sd)	97.9 (14.7)	101.4 (17.8)	t(130.2)=-1.9, *p*=.059
BMI in kg/m^2			
Mean (sd)	35.9 (4.0)	36.4 (5.2)	
Median (IRQ)	35.5 (32.8; 43.9)	34.8 (32.5; 47.6)	Mann-Whitney= .918
Self-regulation score			
Mean (sd)	2.4 (.3)	2.4 (.3)	t(511)=.419, *p*=.676
Target behaviours			
Mean (sd)	3.3 (.50)	3.1 (.53)	t(504)=2.286, *p*=.023

Appendix 7.1 Instructions of how to use the Top Tips apps

TOP TIPS WEIGHT LOSS APP

The Top Tips app was developed by researchers at University College London to help you form **healthy eating habits** and **lose weight**.

Top Tips contains information on simple tips that can be built into your daily routine. The tips help you to take in fewer calories and burn more energy.

Forming healthy habits can be easy. A habit is something you do automatically, like tying your shoelaces or brushing your teeth. Habits are formed when you do something over and over again in the same place or at the same time. Getting into a routine and practising the healthy tips every day, helps turn them into healthy habits.

THE TOP TIPS APP INTERVENTION

TOP TIPS APP:

- Download the app on google play using the link provided to you by email

PASSCODE:

- Make sure you always use the passcode provided to you by email as it is unique to you

START USING THE APP:

- Follow the 4 steps explained in the next page once you start using the app

HOW LONG ARE YOU EXPECTED TO USE THE APP?

- You are expected to use it for 3 months, which is the time required to form habits

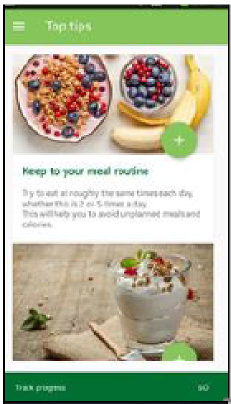
HOW OFTEN ARE YOU EXPECTED TO USE THE APP?

- You should use the app every day and this will require no more than 10 minutes of your time and can be done at a time that suits you

WHAT HAPPENS IF YOU DON'T USE IT FOR A FEW DAYS?

- You can always log completed tips retrospectively

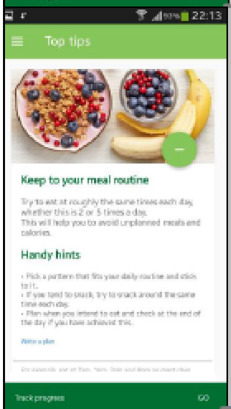
READY TO START? FOLLOW THE NEXT STEPS



STEP

01

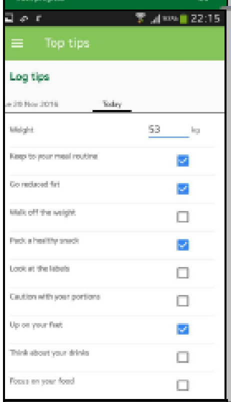
Start reading the information about each of the target behaviours and on how to form healthy habits and make context specific plans.



STEP

02

Enter your own plans for how you are going to fit each tip into your daily routine and don't forget to save your plans. You can always edit your plans if necessary.



STEP

03

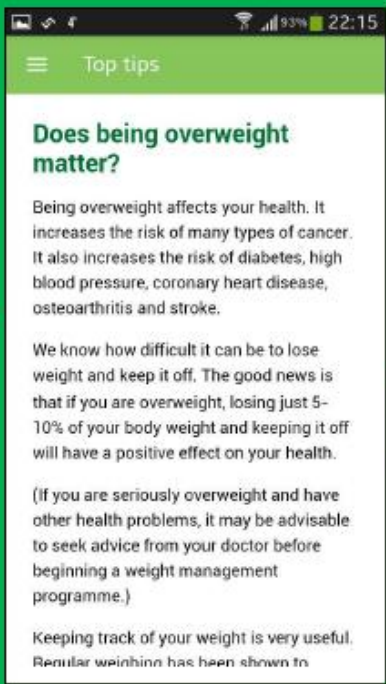
Repeat the tips at the same time and in the same place. This makes it more likely that you will form habits. Weigh yourself regularly and keep track of your weight and how you are doing using the 'logging' page.

STEP

04

Check your weekly progress. Have you managed a tip 5 times a week? Well done you are on track. It takes around **3 months** to form a habit. You may already be doing some of the tips – this is great, keep it up.

TOP TIPS APP HAS MUCH MORE TO OFFER YOU:



BENEFITS OF USING THE APP AND FOLLOWING THE TIPS:

Moderate weight loss (of up to 0.5kg or 1 pound a week)

More energy, less tired.

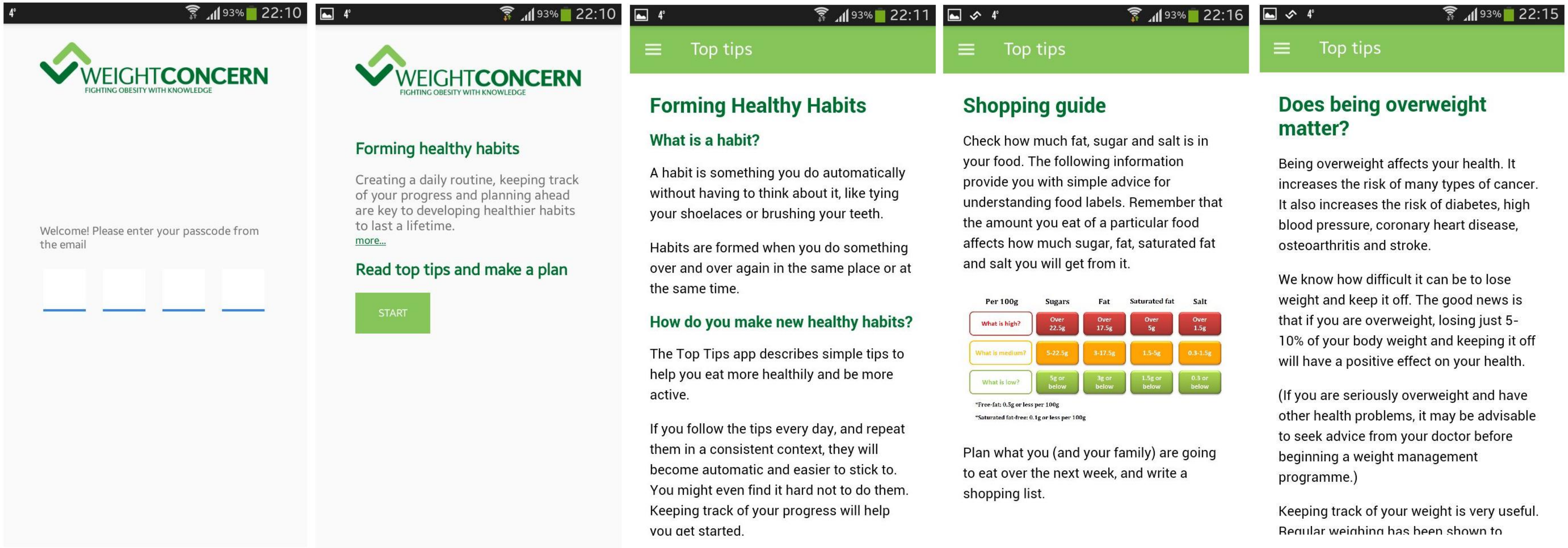
More able to get involved in activities with friends and family.

Reduced risk of developing diabetes, heart disease and some cancers.

Do not hesitate to contact us if you need more information

toptipstrial@gmail.com

Appendix 7.2 Screenshots of the Top Tips app's interfaces which were identical in both versions of the app



Appendix 7.3 Eligibility Survey of the Top Tips App Study

Thank you for your interest in our study.

Please, fill in this short survey, so then we can check whether you meet the inclusion criteria. This should take less than 5 minutes of your time to complete. Once you complete this survey, a member of the research group will contact you by email to give you further instructions about the intervention. If you take part in the research your answers will be anonymous and it will not be possible to identify you from them.

Taking part in the study involves using the TOP TIPS weight loss app for 3 months. Some participants will be able to start straight away while others will be asked to wait for three months to get access to the app. This will allow us to understand if the weight loss app helps people to lose weight or not. Taking part will require no more than 10 minutes per day of your time, and you can use the app at a time that suits you. You will also be asked to fill in a second online questionnaire on 2 occasions: at the start and end of the study. Filling in this second questionnaire should not take longer than 10 minutes.

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 5766/003.

Data will be stored in compliance with the 1998 Data Protection Act, according to UCL ethical requirements.

If you have any questions about the study, please do not hesitate to send an email to Nathalie Kliemann at toptipstrial@gmail.com

If you are happy to take part, please click on 'Next' below. By clicking on 'Next' you are agreeing that:
- You have read the notes written above and you understand what the survey involves
- You should only participate if you want to; choosing not to take part will not disadvantage you in any way
- If you do decide to take part you are still free to withdraw at any time and without giving a reason

1. How old are you?

____

2. What is your current weight approximately? Please give this in stones or kilograms.

Kilograms __________

Or Stones __________

Pounds __________

3. What is your height approximately? Please give this in feet and inches or centimetres.

Centimetres __________

Or Feet __________

Inches __________

4. What kind of smartphone do you own?

Android ☐

iOS	☐
Both Android & iOS	☐
Other	☐
I don't have a smartphone	☐

5. What country do you live in?

England	☐
Wales	☐
Scotland	☐
Northern Ireland	☐
Other	☐

6. Are you currently….

	Yes	No
Pregnant or breastfeeding	☐	☐
Recovering from a Bariatric surgery	☐	☐
Expecting to have bariatric surgery in the next 3 months	☐	☐
On a strict weight loss treatment, such as meal replacements	☐	☐

7. Please, provide your email address to allow us to give you further information and access to the TOP TIPS app intervention. Email addresses will not be passed on or used for other purpose, and will be deleted after the end of the intervention.

Email address	
Repeat your email address	

Now, we would like to ask you a few socio-demographic questions.

8. Are you

Male	☐
Female	☐

9. Are you…

Single	☐
Married	☐
Living as married	☐
Separated	☐
Divorced	☐
Widowed	☐

10. What best describes your ethnic origin?

White	☐
Black	☐
Asian	☐
Mixed	☐
Other	☐

11. What is the highest level of education you have completed or are doing now?

Primary school ☐
Secondary school ☐
O level/ GCSEs ☐
A levels ☐
Technical or trade certificate ☐
Diploma ☐
Degree ☐
Post-graduate degree ☐

12. What is your current employment situation? (tick one that currently takes most of your time)
Employed full-time ☐
Employed part-time ☐
Unemployed ☐
Self-employed ☐
Full-time homemaker ☐
Unpaid/ Voluntary work ☐
Student ☐
Disable or too ill to work ☐
Retired ☐

Thank you very much for completing this survey and for your interest in our TOP TIPS intervention.

We will get in touch soon to give you further information about the intervention and access to the mobile application.

Please, click 'done' to exit.

Appendix 7.4 Baseline Survey of the Top Tips App Study

1. Please, provide your email address to allow us to give you access to the TOP TIPS app intervention. Email addresses will not be passed on or used for other purpose, and will be deleted after the end of the intervention. (Please, enter the same email address you have provided before)

Email address

Repeat your email address

2. In the past two weeks <u>how often</u> you did each of the behaviours below:

		None of the time	**Rarely**	**Some of the time**	**Most of the time**	**All of the time**
1	I ate my meals at roughly the same time every day	□	□	□	□	□
2	I chose reduced fat foods	□	□	□	□	□
3	I used high fat foods only sparingly	□	□	□	□	□
4	I chose healthy snacks rather than an unhealthy snacks	□	□	□	□	□
5	I read the labels when buying foods	□	□	□	□	□
6	I read the labels when preparing foods	□	□	□	□	□
7	I avoided large portions	□	□	□	□	□
8	I avoided second helpings	□	□	□	□	□
9	I stood up for at least 10 min every hour (while awake)	□	□	□	□	□
10	I drank water or sugar-free instead of other soft drinks	□	□	□	□	□
11	I ate at a table	□	□	□	□	□
12	I ate in front of the TV (including snacks)	□	□	□	□	□
13	I drank more than 2 units of alcohol a day	□	□	□	□	□

2. Over the past two weeks on average I have walked:
Less than 2500 steps a day (<15 mins) ☐
About 2500 steps a day (approx 15 mins) ☐
About 5000 steps a day (approx 30 mins) ☐
About 7500 steps a day (approx 45 mins) ☐
About 10000 steps a day (approx 1 hs) ☐
More than 10000 steps a day (>1 hr) ☐

3. In the past two weeks on average I ate a portion of fruits and vegetables (one portion is 80g, e.g. one banana, two satsumas, 2 inches cucumber, 2 tablespoons frozen veg, etc)**:**
O times a day ☐
1-2 times a day ☐
3-4 times a day ☐
5 times a day ☐
More than 5 times a day ☐

4. In the past two weeks I weighed myself on average:

Never ☐
Less than once a week ☐
1-2 times a week ☐
3-4 times a week ☐
5-6 times a week ☐
Every day ☐

5. How many portions of fruit do you usually eat? Please include those eaten at meal times or as snack.(e.g. one apple or banana, a large slice of melon, 2 plums or satsumas, a small bowl of grapes, 3 tablespoons of thinned fruit, or 1/2 tablespoon of dried fruit):

Less than one per week ☐
1 per week ☐
2-3 per week ☐
4-6 per week ☐
1 per day ☐
2 per day ☐
3 or more per day ☐

6. How many portions of vegetables do you usually eat? Please include those eaten at meal times or as snacks (e.g. 2 heaped tablespoons of broccoli or carrots, 3 tablespoons of sweetcorn or peas, or a bowl of salad). Please, do not include potatoes, sweet potatoes or plantains as a vegetable serving.

Less than one per week ☐
1 per week ☐
2-3 per week ☐
4-6 per week ☐
1 per day ☐
2 per day ☐
3 or more per day ☐

7. About how much milk do you use in a day, for example, on cereal, in tea or coffee?

		None	**Less than a quarter-pint**	**About a quarter-pint**	**About half a pint**	**1 pint or more**
1	Whole or Channel Islands	◻	◻	◻	◻	◻
2	Semi skimmed	◻	◻	◻	◻	◻
3	Skimmed	◻	◻	◻	◻	◻

8. <u>How often</u> do you eat/drink the following?

		Never/ rarely	**Once a week**	**2-3 times a week**	**4-6 times a week**	**Once a day**	**Twice a day**	**3 or more times a day**
1	Chocolate and sweets	◻	◻	◻	◻	◻	◻	◻
2	Biscuits, cakes, buns, pastries, ice cream	◻	◻	◻	◻	◻	◻	◻
3	Regular/ non-diet fizzy drinks (e.g. Coke, 7UP)	◻	◻	◻	◻	◻	◻	◻
4	Fruit juice (100% juice/ unsweetened)	◻	◻	◻	◻	◻	◻	◻
5	Other regular/ non-diet fizzy drinks (e.g. squash, fruit drinks)	◻	◻	◻	◻	◻	◻	◻
6	Milkshakes and hot chocolates	◻	◻	◻	◻	◻	◻	◻

9. <u>How many times</u> a week do you eat a serving of the following foods?

		Less than once a week or never	**Once or twice a week**	**3-5 times a week**	**6 or more times a week**
1	Cheese (incl cream cheese, not cottage)	◻	◻	◻	◻

2	Beefburgers and sausages	□	□	□	□
3	Beef, prork, lamb (incl nuts for vegetarians)	□	□	□	□
4	Bacon, meat pies	□	□	□	□
5	Chicken or Turkey	□	□	□	□
6	Fish (not fried)	□	□	□	□
7	Any fried food, fried fish, chips, cooked breakfast, samosas	□	□	□	□
8	Cakes, pies, puddings, pastries	□	□	□	□
9	Biscuits, chocolates and crisps	□	□	□	□
10	Coconut milk/ coconut cream	□	□	□	□

10. About how many <u>rounded teaspoons</u> of margarine, butter, other spread, or oil do you usually use in a day (e.g. on bread, sandwiches, toast, potatoes, vegetables, and in cooking)?

		None	1	2	3	4	5	6	7+
1	Butter, lard or margarine or reduced (not low) fat spread (such as flora spread, Clover, Utterly Butterly)	□	□	□	□	□	□	□	□
2	Low fat spread (e.g. flora, light, Diet Clover)	□	□	□	□	□	□	□	□
3	Oil (Sunflower, olive, palm, rapeseed)	□	□	□	□	□	□	□	□

11. Do you find any of these foods tempting (that is, do you want to eat more of them than you think you should)? (Tick those which apply)

☐	Chocolate
☐	Crisps
☐	Cakes
☐	Ice cream
☐	Bread/toast
☐	Fizzy drinks
☐	Biscuits
☐	Sweets
☐	Popcorn
☐	Pastries
☐	Pizza
☐	Fried foods
☐	Chips
☐	Other foods
☐	I don’t find any food tempting

If you have ticked other foods, please specify:

12. Do you intend NOT to eat too much of these foods you find tempting in the previous question?

Yes ☐

No ☐

13. Do you intend to have a healthy diet?

Yes ☐

No ☐

14. Please read the following statements and tick the boxes most appropriate to you.
For the next few questions, please, understand that:
- ‘Tempting foods’ are any food you want to eat more of than you think your should.
- ‘Eating intentions’ refer to the way you are aiming to eat, for example you may intend to avoid tempting foods or eat healthy foods.

		Never	Rarely	Sometimes	Often	Always
1	I'm good at resisting tempting food	□	□	□	□	□
2	I give up too easily on my eating intentions	□	□	□	□	□
3	I easily get distracted from my eating intentions	□	□	□	□	□
4	I find it hard to remember what I have eaten throughout the day	□	□	□	□	□
5	If I am not eating in the way I intend to I make changes	□	□	□	□	□

15. For the following questions, please choose the response that best describe how you are in terms of food and your eating behaviours:

		Strongly disagree	Disagree	Agree	Strongly agree
1	It's hard for me to notice when I've had enough food	□	□	□	□
2	If I make a resolution to change the way I eat, I pay a lot of attention to how I'm doing	□	□	□	□
3	I can stick to a weight loss plan that works well	□	□	□	□
4	I usually only have to make one mistake with my diet in order to learn from it	□	□	□	□
5	I know how I want to eat healthily	□	□	□	□
6	I have trouble making my mind up about what to do to lose weight	□	□	□	□
7	Often I don't notice what I'm eating until someone calls it to my attention	□	□	□	□
8	When I want to lose weight I can usually think of a number of changes I could make	□	□	□	□
9	I usually keep track of my progress towards my weight loss goals	□	□	□	□
10	When it comes to deciding about a change to the way I eat, I feel overwhelmed by the choices	□	□	□	□
11	As soon as I see a problem in the way I'm eating, I start looking for possible solutions	□	□	□	□
12	I usually think before I eat	□	□	□	□
13	I learn from my diet mistakes	□	□	□	□
14	If I wanted to change how I eat I am confident that I could do it	□	□	□	□
15	I have trouble making plans to help me reach my weight loss goals	□	□	□	□
16	Most of the time I don't pay attention to what I'm eating	□	□	□	□
17	I put off making decisions about my weight	□	□	□	□
18	I am able to resist tempting food	□	□	□	□
19	I'm able to accomplish weight loss goals I set for myself	□	□	□	□
20	I don't notice the effects of my eating behaviour until it's too late	□	□	□	□
21	I have trouble following through with weight loss plans once I've made up my mind to try and lose weight	□	□	□	□
22	I get easily distracted from my weight loss plans	□	□	□	□
23	I have personal standards about eating healthily, and try to live up to them	□	□	□	□
24	I tend to keep doing the same thing, even when it doesn't help me reach my weight loss goals	□	□	□	□
25	I have a lot of willpower when it comes to food	□	□	□	□
26	When I'm trying to change my weight, I pay attention to how I'm doing	□	□	□	□
27	I set weight loss goals for myself and keep track of my progress	□	□	□	□
28	I give up on weight loss plans quickly	□	□	□	□
29	Once I have a weight goal, I can usually plan how to reach it	□	□	□	□
30	I have a hard time setting weight loss goals for myself	□	□	□	□
31	I don't seem to learn from my dieting mistakes	□	□	□	□

Thank you very much for completing this survey.

We will get in touch soon to give you further information about the intervention and access to the mobile application.

Appendix 7.5 Qualitative questions on users' experience

1. What are your overall views toward the 10TT app?

2. Was there anything you particularly disliked?

3. Was there anything you found particularly hard to use?

4. Was there anything you particularly liked?

5. Was there anything you found particularly easy to use?

6. Anything you wanted to see there/expected to see there but didn't?

7. Do you have any suggestions for how the app could be improved?

8. Are there any other comments you would like to make?