

**Novel multi-method approach  
investigating behaviour change  
maintenance**

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## Thesis abstract

**Background:** Behaviour change, if maintained, can lead to significant health improvements. The aim of this thesis was to advance psychological theory of behaviour change maintenance and the design of behavioural interventions to improve health. This thesis used a novel multi-method approach to explore behaviour maintenance, with a particular focus on weight loss maintenance (WLM).

**Methods:** A three stage, multi-method approach included: (1) A systematic review of behavioural theories to identify theoretical explanations for behaviour maintenance and to examine the relationships between these explanations; (2) An *N-of-1* study of WLM assessing theoretical predictors of maintained behaviour based on the systematic theory review, which employed ecologic momentary assessment, wireless body scales, and activity monitors in 12 obese people who had lost at least 5% weight in the previous year, analysed through cross-correlations of time series; (3) Data-prompted semi-structured, longitudinal interviews with individuals who participated in the *N-of-1* study to explore their experiences of WLM, prompted by personal data including summaries of *N-of-1* data, pictures, notes and graphs, analysed using the Framework method.

**Findings:** (1) Systematic review: out of 117 identified behaviour theories, 100 met the inclusion criteria. The main theoretical themes identified to underpin behaviour change maintenance included maintenance motives, self-regulation, habits, psychological resources and environmental/social influences; (2) *N-of-1* study: for 12 participants a range of maintenance-related theoretical variables showed differential impact on ability to maintain weight, engage in physical activity and

follow a personal WLM plan. The combination of predicting variables that had significant impact on outcome variables was unique for each individual; (3) Data-prompted interviews: most of the theoretical explanations from the systematic theory review adequately accounted for participants' experiences. Additional emergent themes included: competing goals, prioritising, and preparatory strategies that enhanced self-regulation. Using personal data summaries proved valuable in evoking narratives regarding unique experiences of WLM.

**Discussion:** A range of theoretical explanations were identified and proved useful in explaining behaviour maintenance in the area of WLM. The main conclusion derived from the thesis is that behavioural interventions need to tap into relevant behavioural explanations and deliver intervention components in a timely manner to support individuals to maintain behaviour change. Interventions should include elements of choice and customisation and should be adaptable to personal needs. The main study strengths included employment of novel methods and technology. The main limitation included *N-of-1* analytical challenges and scalability of the applied design. Future research should develop behaviour maintenance theory further and explore which combinations of WLM strategies, in which individuals, support effective WLM.

## **Publications and presentations arising from this thesis**

**Kwasnicka, D.,** Dombrowski, S. U., White, M., & Sniehotta, F. F. (2015). A qualitative data-prompted study of weight loss maintenance experiences using individual ecological data. Presented at the 29th European Health Psychology Society Conference, Limassol, Cyprus. Oral presentation.

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**Kwasnicka, D.**, White, M., Dombrowski, S. U., & Sniehotta, F. F. (2013). Looking at behaviour change maintenance from the theoretical perspective. Presented at the UKCRC Public Health Research Centres of Excellence (PHRCoE) 4<sup>th</sup> Annual Conference, Cardiff, Wales. Poster presentation – received best poster prize.



## **List of abbreviations**

BCT - behaviour change technique

CI - confidence interval

DPI - data-prompted interview

HAPA - Health Action Process Approach

LQI - Longitudinal Qualitative Interviews

NHS - National Health Service

NICE - National Institute for Health and Care Excellence

NWCR - National Weight Control Registry

RCT - randomised controlled trial

SD - standard deviation

SMS - short message service

UK - United Kingdom

US - United States

WHO – World Health Organisation

WLM - weight loss maintenance



# **Chapter 1 Introduction: Behaviour change maintenance and weight loss maintenance in policy and in behavioural research.**

## **1.1 Background and area of study**

### **1.1.1 Public health and weight management**

In both high and low income countries, obesity rates have increased in the last 30 years (Finucane et al., 2011). Globally, more than 1.4 billion adults are overweight and more than half a billion are obese (World Health Organization, 2015c). If recent trends continue, it is estimated that by 2030, 2.16 billion people will be overweight and 1.12 billion will be obese (T. Kelly, Yang, Chen, Reynolds, & He, 2008). Excessive weight is associated with disease; worldwide 23% of ischaemic heart disease, 44% of type II diabetes and 7-41% of specific cancers are linked to being overweight or obese (World Health Organization, 2015c). The combined medical costs associated with the treatment of these diseases are rising, and they are estimated to increase radically by 2030 (Wang, McPherson, Marsh, Gortmaker, & Brown, 2011).

In the UK 62% of adults are currently overweight and 26% of these are obese (Department of Health, 2013c), with these trends suggestive of an 'obesity epidemic'. Health problems associated with being overweight or obese have been estimated to cost the UK National Health Service (NHS) more than £5 billion per year (Department of Health, 2013c). The Foresight report looking at how society should respond to rising levels of obesity in the UK recommends social change at multiple levels: personal, family, community and national (Butland et al., 2007).

There are multiple causes of obesity including genetic, behavioural and environmental determinants. The main behavioural determinants of obesity include a lack of physical activity (Manson, Skerrett, Greenland, & VanItallie, 2004), and a diet high in calorie-dense foods (Cecchini et al., 2010). Environmental influences include a significant change in the global food system, producing widely available, highly processed and well marketed foods (B. A. Swinburn et al., 2011). Although personal responsibility plays a role in weight gain, people are often overwhelmed by the environment, with its prevalence of energy dense food, motorised transport and sedentary lifestyles (Butland et al., 2007). As a result, people living in the UK and in many other high-income countries are becoming heavier. This process has been coined 'passive obesity', meaning that normalisation of obesity is triggered by environmental context, and leads to every generation becoming heavier than the previous one (Butland et al., 2007). Behavioural and environmental causes of obesity are interrelated and require behavioural and contextual interventions and changes (B. A. Swinburn et al., 2011).

Obesity is preventable and treatable, and can be reduced by behavioural interventions, including a decrease in energy intake combined with physical activity (Prentice & Jebb, 2004). A wide range of evidence shows that healthy eating defined in terms of natural, minimally processed foods, predominantly plants, is associated with better health outcomes (D. L. Katz & Meller, 2014). Sustained physical activity helps to maintain healthy weight and decrease disease at the population level (Manson et al., 2004). Supportive environments and communities

are crucial in the architecture of food choice and activity promotion (B. A. Swinburn et al., 2011; Thaler & Sunstein, 2008). Many stakeholders are involved in encouraging people to achieve optimal weight, including international organisations, governments, the private sector and charities (Gortmaker et al., 2011). In view of the current obesity epidemic, losing excess weight and promoting sustained weight loss are urgent goals on public health agendas (Caballero, 2007).

### **1.1.2 Weight loss maintenance in current policy**

Behavioural and contextual changes have the potential to decrease excess weight at the population level. Several policy documents recommend that an initial change of health-related behaviour and context can cause significant health improvement, particularly if changes in behaviour are maintained, and if the contextual changes are accepted. The World Health Organization (2015c) provides recommendations for country-specific health policies. In terms of diet policy, they advise that people should aim to achieve energy balance and a healthy weight; to limit energy intake from fats, especially saturated fats; to increase their consumption of fruit and vegetable, legumes, whole grains and nuts; and to limit their intake of sugar and salt (World Health Organization, 2015c).

Similar policy guidance exists in the UK, where the government's stated aim to encourage and help people to eat and drink more healthily, to be more active and less sedentary (Department of Health, 2013c). The Department of Health provides recommendations on the maintenance of healthy diet and physical activity through the Change4Life programme (Change4Life, 2015), by improving labelling on food

and drink products (Department of Health, 2013a), and by encouraging businesses and organisations to support people to make healthy choices (Department of Health, 2013b).

The National Institute for Health and Care Excellence (NICE) emphasises the need to work with local communities to help people maintain a healthy weight (NICE, 2012a), alongside the importance of developing individual approaches (NICE, 2014a). The guidance addressing working with local communities (NICE, 2012a) focuses on establishing sustainable community-wide actions for the prevention of overweight and obesity by, setting out how organisations and networks can support their local community to promote healthy weight. The guidance on individual approaches (NICE, 2014a) places an emphasis on personal responsibility for health behaviour change; including suggestions for improving diet, becoming more physically active and losing weight if people are overweight or obese.

The World Health Organization (2015b) also provides guidance on recommended levels of physical activity. Physical activity includes sports and exercise but also household activities, walking, and gardening. For adults (18–64 years) the current recommendation is to undertake at least 150 minutes of moderate intensity physical activity per week (e.g. brisk walking, cycling), or at least 75 minutes of vigorous intensity physical activity per week (e.g. running, playing football). Muscle-strengthening activities such as weight lifting should be done on two or more days per week. These activities should be performed in bouts of at least 10 minutes to maximise the health benefits. For additional health benefits, the World Health

Organization (2015b) suggests that the amount of physical activity listed above should be at least doubled. For older adults (65 years and above) similar recommendations are issued, taking into consideration that if they have any health conditions which prevent them from being physically active, their activity should be in line with their abilities. It also recommends that they should also perform physical activity that enhances balance to prevent falls on three or more days a week.

Recommendations from the UK government are similar, with an additional recent emphasis placed on minimising the amount of time that people spend being sedentary (sitting or lying) (Department of Health, 2011c). Walking and cycling are strongly promoted as forms of travel and recreation (NICE, 2012b). A gradual increase of activity is recommended for weight loss; however there are no specific recommendations for physical activity levels for weight loss maintenance.

The WHO recognises that improving diet and increasing physical activity is a societal issue, therefore it demands a population-based, multidisciplinary, and culturally relevant approach (World Health Organization, 2015c). The UK Department of Health (2013c) echoes this message, and sets out plans for involving the whole of society in reducing excess weight, and helping people to maintain their weight loss (NICE, 2014b).

### **1.1.3 Definitions of behaviour change maintenance and weight loss maintenance**

Health improvement depends on the implementation of behavioural and contextual changes that lead to significant changes in behaviour which then produce a change in the outcome, i.e. health status. Behaviour change has been defined in terms of transformation or modification of human behaviour (Michie, van Stralen, & West, 2011). Health behaviour change aims to modify individual, community and contextual approaches that influence behaviour in order to enhance health status of individuals (Pbert, 2013).

Health behaviour change can be achieved through behaviour change interventions. Behaviour change interventions have been defined as coordinated sets of activities designed to change specified behaviour patterns, measured as the prevalence or incidence of specific behaviours in populations (Susan Michie, Maartje M. van Stralen, et al., 2011), e.g. delivery of nutritional advice session by a practice nurse. Behaviour change interventions tackling health problems can significantly improve health if they are effective in changing the behaviour, and if the behaviour change is maintained.

For the purpose of this thesis, behaviour change maintenance is defined as the sustained performance of a behaviour following an initial behaviour change at a level that significantly differs from the baseline performance in the intended direction, For instance, the maintenance of healthy eating practices or maintenance of physical activity.



Weight loss maintenance (WLM) has been defined as a process of sustaining a significant intentional weight loss accomplished by one's own efforts or as a result of treatment (Elfhag & Rössner, 2005). The specific criteria used to define WLM vary between theories and research studies. Key discrepancies include the percentage of weight loss required, and the length of time for maintained weight loss. For instance in terms of percentage weight loss, WLM researchers suggest that a minimum of 3% (J. Stevens, Truesdale, McClain, & Cai, 2005), 5% (D. Crawford, Jeffery, & French, 2000) or 10% (Wing & Hill, 2001) is necessary to be classified as a significant WLM. The time period requirements for substantial WLM also differ, for example a minimum of 6 months (Elfhag & Rössner, 2005), 12 months (Wing & Hill, 2001) or 24 months (J. Stevens et al., 2005) of maintained weight loss have all been specified by previous research. Some studies classify people as successful or not in WLM on the basis of losing and maintaining more than two body mass index points (Cuntz, Leibbrand, Ehrig, Shaw, & Fichter, 2001).

In this thesis WLM is defined in terms of the intentional weight loss of at least 5% of body weight (weight loss reported as required to achieve health benefits) with no restrictions applied in terms of the time period needed for maintenance. There is a limited understanding of the behavioural processes underpinning WLM. Therefore a better understanding of behaviour change maintenance is desirable to design interventions that support WLM.

#### **1.1.4 Long term weight loss studies**

A range of research has shown that weight loss interventions can be effective in successfully supporting people's behaviour change in relation to dietary and activity patterns to induce weight loss (systematic reviews of weight-loss interventions: Curioni & Lourenco, 2005; Douketis, Macie, Thabane, & Williamson, 2005; Franz et al., 2007). Weight loss leads to improvements in health, but these improvements can only be sustained if lost weight is kept off (Jolly et al., 2011; Penn et al., 2013). However, despite the encouraging outcomes from successful weight loss interventions, people tend to regain their weight loss relatively quickly. A systematic review has shown that people on average regained a third of their initial weight loss within a year and the rest within 3-5 years (Avenell et al., 2004). Another systematic review reported that on average, half of the initial weight loss was regained after one year (Curioni & Lourenco, 2005). Effective interventions promoting WLM are therefore required.

##### **1.1.4.1 Reviews of WLM studies**

To maintain weight loss, specific changes in physical activity and diet also need to be maintained. Fjeldsoe, Neuhaus, Winkler, and Eakin (2011) assessed how frequently trials report on maintenance of behaviour change in physical activity and/or diet. The authors examined outcomes of 157 trials, and of these only 55 (35%) included a post-intervention follow-up of 3 months or longer, defined as the minimum period required for behaviour change maintenance. Maintenance of

physical activity and dietary behaviour change was often not reported or not assessed in the studies.

A narrative review of the WLM literature has shown that weight regain following weight loss on a population level is common, and long term interventions showed only modest effects (Simpson, Shaw, & McNamara, 2011). Notably, this review was unsystematic in terms of study identification and inclusion of non-randomised studies. Another systematic review of 13 randomised controlled trials (RCTs) of WLM interventions showed an average -3.2 kg weight loss difference over 17.6 months post-intervention in participants provided with extended care, compared with controls (Ross Middleton, Patidar, & Perri, 2012). In this review, however the number of included studies was relatively small (n=13) and more than half of the included studies were conducted by the same research group.

A recent comprehensive systematic review reported more modest results, with interventions promoting long term maintenance of weight loss showing an average difference of -1.56 kg (95% CI -2.27 kg to -0.86 kg; including 25 comparisons in 1,949 participants) weight regain at 12 months compared to controls (S.U. Dombrowski, Knittle, Avenell, Araújo-Soares, & Sniehotta, 2014). The same review provided some evidence that weight loss can be sustained for 24 months (mean difference in weight -1.96 kg; 95% CI -2.73 kg to -1.20 kg), but there was limited evidence beyond this time period. This review mainly included studies from the United States (US) and from Scandinavian countries; not a single study included was conducted in the UK.

#### **1.1.4.2 Features of successful WLM interventions**

The effectiveness of WLM interventions potentially relates to the appropriateness of intervention mode, provider, and components. There is no evidence that more intensive interventions, defined in terms of higher frequency of contact or number of intervention components, are more effective than less intensive interventions (Dale et al., 2009; Lowe et al., 2008). Internet-delivered behavioural interventions have not been found to show a significant difference compared to control groups (Cussler et al., 2008; Svetkey et al., 2008). Although face-to-face interventions have shown a tendency to be more effective than those remotely delivered (using the telephone or on-line), the difference was not significant (Harvey-Berino, Pintauro, Buzzell, & Gold, 2004; Wing, Tate, Gorin, Raynor, & Fava, 2006). Preferences for the mode of delivery and intensity of intervention were likely to vary between individuals, and mode of delivery in WLM studies seems to have only a marginal effect on weight outcomes (S.U. Dombrowski et al., 2014).

Certain trials provided support for the effectiveness of specific behaviour change techniques (BCTs) used to support people to maintain weight loss. The effective techniques were: providing peer, social and professional support (Svetkey et al., 2008; Wing et al., 2006); goal setting (Svetkey et al., 2008); self-monitoring (Burke, Wang, & Sevick, 2011); and relapse prevention and problem solving (Perri et al., 2001). A recent study showed that daily self-weighing was ineffective as a weight loss intervention (Madigan, Jolly, Lewis, Aveyard, & Daley, 2014); not surprisingly the study showed that individuals need additional support to aid their weight loss.

Daily weighing, however, has been shown to be supportive in WLM (LaRose et al., 2013; Madigan et al., 2013; Wing et al., 2006). Several qualitative studies have reported pronounced differences between successful and unsuccessful weight loss maintainers in the strategies they used to maintain weight (Barnes et al., 2007; Byrne, Cooper, & Fairburn, 2003; Kayman, Bruvold, & Stern, 1990; Reyes et al., 2012). In these studies, characteristics associated with successful WLM were: mindfulness and awareness of WLM; coping planning; relying on habit in exercise and eating routines; and using social support.

#### **1.1.5 Personality traits in relation to WLM**

Personality traits are defined by emotional, cognitive, and behavioral patterns that are likely to impact on WLM outcomes. There are several personality traits that may impact on WLM including neuroticism, impulsivity, psychological flexibility, and optimism. In a large longitudinal survey ( $N=1,988$ ) which lasted for 50 years and examined how personality traits are related to fluctuations in BMI (Sutin, Ferrucci, Zonderman, & Terracciano, 2011), the researchers modelled the relationship between personality traits and BMI across the life span. The results showed that people who were rated higher on neuroticism or extraversion, or lower on conscientiousness, had higher BMI, while low conscientiousness and high neuroticism were strongly associated with difficulties in impulse control. There was a very strong relationship between impulsivity and BMI, with people who scored in the top 10% on impulsivity being on average 11kg heavier than people who scored in the lowest 10%.

Another personality characteristic reported as potentially important for weight outcomes is psychological flexibility. There have been mixed results in terms of the influence of psychological flexibility on WLM outcomes. For instance some authors have suggested that individuals who allow for dietary flexibility increase their exposure to high-risk situations by creating opportunities to lose control over food and drink being consumed, as compared to individuals who maintain a consistent diet regimen (Wing & Phelan, 2005). Conversely, other authors have shown that restrained eaters are much more likely to overeat than unrestrained ones, due to constant suppression of food-related thoughts, meaning that they are then primed to eat more (Stroebe, Mensink, Aarts, Schut, & Kruglanski, 2008). Therefore, psychological flexibility may in fact facilitate WLM.

Another personality trait reported as relevant to WLM outcomes is optimism. It is often mistakenly claimed that setting realistic weight goals helps to lose and maintain weight (Casazza et al., 2013); however there is no robust evidence to support this claim. In contrast, there is evidence showing that being overly optimistic regarding future weight may improve weight outcomes (Linde, Jeffery, Finch, Ng, & Rothman, 2004). In a study based on a self-report questionnaire that assessed 302 adult women enrolled in a weight loss trial, higher weight loss goals were associated with a greater long-term weight loss, as were optimism, better mood and confidence in success (Linde et al., 2004). In summary, certain personality traits are strongly associated with weight loss outcomes and there are specific personal characteristics which may both facilitate or hinder WLM.

### **1.1.6 Long term studies assessing physical activity maintenance**

Evidence about the type and amount of physical activity to support WLM is limited. A systematic review of prospective studies and randomised weight loss interventions showed inconsistent results for the effects of increased physical activity on weight change (Fogelholm & Kukkonen-Harjula, 2000). The mean regain of body weight in included RCTs was 0.28 kg per month in conditions with physical activity, compared to 0.33 kg per month in conditions without a physical activity component (Fogelholm & Kukkonen-Harjula, 2000). In the same review, results from the observational studies showed that increased energy expenditure of approximately 1500–2000 kcal per week through physical activity was associated with improved weight maintenance outcomes.

The factors that differentiated successful physical activity maintainers from relapsers were higher self-efficacy and higher intention levels (Amireault, Godin, & Vézina-Im, 2013). Health status has been shown to directly affect physical activity maintenance and moderate the relationship between body mass index (BMI) and education, as well as perceived negative consequences and physical activity maintenance (Amireault et al., 2013). Physical activity maintenance had greater impact on weight for women than men (Hankinson et al., 2010). Comparisons between 3,554 men and women aged 18 to 30 years at baseline have shown that maintenance of higher activity levels over 20 years, compared to lower activity levels, was associated with smaller gains in BMI among men and women as they transitioned from young adulthood into middle age. Men and women maintaining

higher activity gained respectively 2.6 kilograms and 6.1 kilograms fewer over 20 years than the low-activity group (Hankinson et al., 2010).

#### ***1.1.6.1 Features of successful physical activity maintenance interventions***

In a systematic review of studies exploring determinants of initiation and maintenance of physical activity among older adults, goal setting, planning and action control were found to be probable predictors of both initiation and maintenance of physical activity (van Stralen, De Vries, Mudde, Bolman, & Lechner, 2009). Other determinants of physical activity differed for initiation and maintenance; for instance outcome expectations were shown to influence physical activity initiation, but not physical activity maintenance (van Stralen et al., 2009). Implementation intentions were associated with increased physical activity initiation, showing small to moderate effects (Bélanger-Gravel, Godin, & Amireault, 2013), whereas coping planning seemed to strongly predict longer-term physical activity maintenance (van Stralen et al., 2009). Interestingly, social modelling, social norms and social support received from family and friends, were found to be important during initiation, whereas support from health care providers, sports instructors, and other exercise group members appeared to be more important for physical activity maintenance (van Stralen et al., 2009).

Behaviour monitoring and goal setting (e.g. 10,000 steps per day) was found to be associated with an increase in physical activity, and physical activity maintenance. For instance giving people pedometers increased physical activity levels (Bravata et al., 2007). In a systematic review of 26 studies with a total of 2,767 participants,



pedometer users significantly increased their step count on average by 2,491 steps per day compared with controls (95% CI, 1,098-3,885 steps per day,  $p < .001$ ). In the observational studies, pedometer users increased their step count on average by 2,183 compared to controls (95% CI, 1,571 to 2,796 steps per day,  $p < .0001$ ). An important predictor of increased physical activity was specifying a goal, e.g. 10,000 steps per each day (Bravata et al., 2007). Similar outcomes were found in interventions promoting physical activity goal setting in worksite interventions; specific goal setting and goal review techniques were associated with enhanced fitness gains (Abraham & Graham-Rowe, 2009). There are specific features linked to the successful interventions promoting WLM and physical activity maintenance. However, underlying mechanisms explaining how people maintain the change and person-specific characteristics require further investigation.

#### ***1.1.6.2 Exploring characteristics of successful weight loss maintainers***

The National Weight Control Registry (NWCR) established in the United States investigates behavioural and psychological characteristics of a self-nominated cohort of people who successfully maintain their weight loss (Wing & Phelan, 2005). The study surveys over 10,000 participants every year to assess the characteristics of successful weight loss maintainers. To maintain their weight loss, NWCR participants report eating a low fat and low calorie diet, eating breakfast regularly, engaging in high levels of physical activity, self-monitoring weight, and maintaining consistent eating patterns (Wing & Phelan, 2005). The NWCR limitations include self-referral of the participants, unjustified emphasis on calorie-restricted dieting,

and study findings are not dissimilar from general recommendations for weight loss (Ikeda et al., 2005). A more intricate understanding of what variables make these individuals successful in their WLM would help the design of WLM interventions by highlighting which variables need to be targeted.

### **1.1.7 Technology and weight loss maintenance**

Alongside the more traditional methods of delivering behaviour change interventions, e.g. face-to-face, recent technological advances have made it possible to use newly developed technologies to engage in alternative ways of delivering weight loss and WLM interventions. Novel technologies can be used to research and intervene in human behaviour, and their advantages include reach, scalability, and cost-effectiveness. A wide range of programmes and modern technologies have been used to support people to lose and subsequently maintain the weight loss. Examples include: on-line information and support platforms; phone or text messaging systems; mobile phone, tablet or computer applications (apps); monitoring devices including weight trackers; activity monitors and sensors; and social media, mainly involving Twitter and Facebook.

In a review of technology-based weight management interventions, the following key components were identified: self-monitoring; feedback and contact with an expert; social support; and structured, individually tailored programs (Khaylis, Yiaslas, Bergstrom, & Gore-Felton, 2010). Short-term results from weight-loss interventions using these components and employing technology have been promising. However, long-term results are more mixed (Khaylis et al., 2010). Recent

evidence for using technology to support weight control is presented below for on-line support, text messages, apps, monitoring devices, and social media.

#### **1.1.7.1 *On-line interventions***

Weight management programs and interventions are often delivered on-line, and more frequent usage of website features is usually associated with greater weight loss (Neve, Morgan, Jones, & Collins, 2010). A systematic review of internet-based interventions promoting health behaviours showed that those employing a greater number of BCTs had bigger effects than on-line interventions incorporating fewer BCTs (Webb, Joseph, Yardley, & Michie, 2010). The effectiveness of internet-based interventions was enhanced by the use of additional methods of communicating with individuals, especially the use of text messages (Webb et al., 2010).

#### **1.1.7.2 *Text messages***

A systematic review of RCTs and quasi-experimental intervention trials that used the short message service (SMS) as an intervention medium for weight management showed that SMS was a well received and commonly accepted medium of communication, although the effectiveness of text messaging interventions varied (Shaw & Bosworth, 2012). Text messages were reported as quick and easy to set up, and inexpensive to provide, although they were mainly used as an additional tool rather than a core aspect of weight management programme. A meta-analysis of RCTs that investigated the efficacy of SMS messages to enhance healthy behaviour showed that SMS messages had a small, positive, and significant effect on a broad range of healthy behaviours (0.29). This effect was

maximised when multiple SMS messages per day were sent (0.39) compared to other lower frequencies (0.24) (Orr & King, 2015).

### **1.1.7.3 Mobile phone applications**

Reviews of the effectiveness of various mobile phone applications used to support weight management have shown promising effects (Årsand et al., 2012; Okorodudu, Bosworth, & Corsino, 2014) supporting goal setting, self-monitoring, problem solving, and reinforcement tactics. The reviews of mobile phone apps supporting weight loss and maintenance showed, however, that mobile phone apps include only a limited number of behavioural strategies, delivering insufficient evidence-informed content (Breton, Fuemmeler, & Abrams, 2011; Pagoto, Schneider, Jovic, DeBiasse, & Mann, 2013). The most frequent types of support included in the apps ( $N=204$ ) were: diet, physical activity, and weight monitoring (19%); dietary advice and monitoring (34%); and weight tracking (46%) (Breton et al., 2011).

Another review of the top 20 paid and 20 unpaid physical activity and/or behaviour apps available in the 'Health and Fitness' category in New Zealand's app store, showed that apps on average included 8.1 BCTs and the average was higher for paid (9.7) versus unpaid (6.6) apps (Direito et al., 2014). The BCTs most frequently included were providing instructions (83% of apps), setting a graded task (70%), and prompting self-monitoring (60%). Techniques which were not included were: teaching to use cues and prompts to action; agreeing on the behavioural contract; preventing relapse; and managing time. Furthermore, behavioural strategies that

improve motivation, problem solving and help to reduce stress, were not included in the apps, although according to the most recent evidence, they would prove beneficial (Pagoto, Schneider, Jojic, et al., 2013).

#### **1.1.7.4 Devices and sensors**

Several devices can be used to support weight management, including weight trackers and scales, activity monitors and sensors. A wide variety of methods have been used to perform self-monitoring, mainly focusing on diet, exercise, and self-weighing (Burke et al., 2011). Weight tracking can be performed using digital scales that detect weight automatically and provide output to platforms such as websites or apps. Examples of scales that allow weight tracking include Fitbit Aria, BodyTrace, and Withings (Gilmore, Duhé, Frost, & Redman, 2014). Users need to open an on-line account where they can monitor their performance, and the device usually synchronises with the recipient platform via Bluetooth. The same principle works for activity trackers such as Fitbit, Nike+, and BodyMedia Fit. Weight and activity trackers can be synchronised together and they can also link to a food diary, which can be self-reported (e.g. taken from a food database) or imputed with QR code-scanning technology e.g. MyFitnessPal (Yusof & Iahad, 2012). Recent studies have shown that individuals want to use and control their personal sensor data, although only some of the commercially available devices provide this facility; and personal preferences varied across different devices (Barua, Kay, & Paris, 2013). Users of novel devices and sensors have joined a new era of weight management, often relying on technology to support weight loss and maintenance.

### **1.1.7.5 Social media**

The increasingly popular social media can play a role in aiding sustained weight loss, shaping public opinions and promoting healthy behaviours. For instance a recent study has shown that a brief exercise intervention can spread easily via social networks and can be tracked and reinforced on-line (#PlankADay study: Pagoto, Schneider, Oleski, Smith, & Bauman, 2013). Conversely, social media can also have a negative impact, mainly due to the anonymity of users (Christopherson, 2007). A study conducted to describe social media interactions regarding excess weight, collecting two months data and gathering 2.2 million posts, showed that Twitter represented the most common channel to talk about excess weight (W.-y. S. Chou, Prestin, & Kunath, 2014). Both Twitter and Facebook were dominated by negative messages stigmatising people in relation to their body weight; blogs and forums contained more restrained comments (W.-y. S. Chou et al., 2014). Social media are yet to be explored through research on weight loss management. However the small body of research findings in this area suggest that searching skills and selectivity create a more positive experience (Christopherson, 2007).

The use of technology in weight management programmes leads to improved long-term results, and in most cases improved cost-effectiveness (Gilmore et al., 2014). Digital health technologies including mobile phones, sensors, and online social networks can be used to intervene and to research and understand health behaviour through gathering real-time data (Pagoto & Bennett, 2013). However although increasingly popular, weight maintenance technologies may lack

comprehensive evidence-informed recommendations and rigorous evaluations for healthy weight management (Breton et al., 2011). Currently there are no industry standards for technology developers who provide support for health behaviour change and maintenance. An evidence-based framework for technology developers and programme providers combining up-to-date evidence from psychology, public health and digital science could substantially improve weight outcomes at the population level. Modern technology can be used to research and monitor human behaviour and to intervene in real-time. Rather than simply placing the blame for recent population weight increases on technology (e.g. increase in sedentary activities, and availability of highly processed foods) recent innovations can be used to battle the obesity epidemic.

## **1.2 Rationale for the research**

To date, much attention has focussed on studies researching weight loss (Douketis et al., 2005; Franz et al., 2007). Extensive evidence shows that people are able to successfully lose weight with clinically significant health improvements (Avenell et al., 2004; Blackburn, 1995). However, there is a lack of robust evidence regarding predictions and explanations for long term WLM (S.U. Dombrowski et al., 2014). Thus far, no study has systematically reviewed the explanations for why some people are successful with maintaining new health behaviours after significant change, while others relapse to their previous behaviours. Summarising theories of sustained behaviour has the potential to structure and direct future behaviour

change interventions which are aimed at behaviour maintenance (Alexander J. Rothman, 2004).

To combat the obesity epidemic public health efforts are focused on healthy weight promotion (Caballero, 2007). However people who have successfully lost weight are at high risk of reversing to previous unhealthy behaviours (Avenell et al., 2004; S.U. Dombrowski et al., 2014). Sustaining healthy weight and maintaining healthy lifestyle are key aims of current health policy (Butland et al., 2007). Research efforts are also now concentrating on exploring predictions for maintained weight loss (Sniehotta, Simpson, & Greaves, 2014). Using technology will assist this process by providing the opportunity to obtain rich data from individuals.

Novel technologies allow us to explore human behaviour, often providing real-time data and giving extensive information (Heron & Smyth, 2010). Technology is frequently used to aid weight management, and its application in weight-related research is rising (Gilmore et al., 2014; Pagoto & Bennett, 2013). None of the empirical studies reported to date combine assessment of outcomes and cognitions in real-time ecological momentary assessment (Saul Shiffman, Stone, & Hufford, 2008) with collecting participant-generated data - proactive experience sampling (Christensen, Barrett, Bliss-Moreau, Lebo, & Kaschub, 2003), and real-time weight and activity monitoring (using Wi-Fi connected sensors) to explore predictions of maintained weight loss.

Moreover, to our knowledge, none of the existing studies combined participant information gathered in real-time regarding weight, activity, experiences and



cognitions and used it to provoke narratives during the interviews assessing WLM experiences.

### **1.3 Research questions and overview of the thesis**

The overarching aim of this work is to advance understanding of psychological theory of behaviour maintenance to facilitate the design of behavioural interventions to improve health. The main objective of this study is to examine behaviour maintenance processes in people who have successfully lost clinically significant amounts of weight (at least 5% of body weight).

This research has three main research questions:

1. What are the existing theoretical predictions and explanations of behaviour change maintenance?
2. What are the individual predictors of adherence to or deviation from a self-imposed WLM regime?
3. What are the advantages and disadvantages of using individual-specific data in data-prompted interviews assessing WLM?

Subsequent chapters aim to answer each of the aforementioned research questions.

**Chapter 2** will present a structured systematic review of behavioural theories that address behaviour change maintenance. Relevant theories will be identified and their key theoretical themes will be explored. Emerging theoretical themes will be assessed further in the empirical chapters.

**Chapter 3** will introduce a series of 12 single-case studies (*N*-of-1s) that will be used to explore potential explanations for sustaining weight loss or for relapse. Main outcomes measured will be weight, physical activity and self-reported adherence to the WLM plan. The results of the study will show if fluctuations in each of these three outcomes are predicted by explanatory variables included in theories of behaviour change maintenance.

**Chapter 4** will describe a novel method of conducting interviews using participant data in the form of notes, pictures, and graphs presenting daily measures of outcomes. The advantages and disadvantages of data-prompted interviews will be discussed.

**Chapter 5** will present the outcomes of data-prompted interviews following the multimodal study of WLM. Quantitative and qualitative data will be presented to participants during the interviews. Interviews will be analysed using the Framework method, applying pre-specified maintenance-relevant theory-based variables. In this chapter, experiences of and strategies used during WLM will be explored.

**Chapter 6**, the final section of the thesis, will provide a discussion of the main findings of this research, assessing how the research fits with current global and UK policy, and with national recommendations. The strengths and limitations of the thesis will be discussed. The thesis will conclude by identifying recommendations for policy, practice and future research in the domain of weight loss and behaviour change maintenance.

## **Chapter 2 Theoretical explanations for maintenance of behaviour change: a systematic review of behaviour theories.**

### **2.1 Abstract**

**Background:** Behaviour change interventions are effective in supporting individuals in achieving temporary behaviour change. Behaviour change maintenance, however, is rarely attained. The aim of this review was to identify and synthesise current theoretical explanations for behaviour change maintenance to inform future research and practice.

**Methods:** Potentially relevant theories were identified through systematic searches of electronic databases (Ovid MEDLINE, Embase, PsycINFO). In addition, an existing database of 80 theories was searched, and 25 theory experts were consulted. Theories were included if they formulated hypotheses about behaviour change maintenance. Included theories were synthesised thematically to ascertain overarching explanations of behaviour change maintenance. Initial theory themes were externally cross-validated.

**Findings:** A total of 117 behaviour theories were identified of which 100 met the inclusion criteria. Five overarching, interconnected themes of theoretical explanations for behaviour change maintenance emerged related to maintenance motives (emphasizing self-determination; satisfaction with behaviour outcomes and behaviour enjoyment; identity and congruence with beliefs and values); self-

regulation; resources (psychological and physical); habit development and environmental and social influences.

**Discussion:** Theoretical explanations of behaviour change maintenance focus on differential roles of motives, self-regulation, resources, habit, and environmental/social influences from initiation to maintenance. Future research should assess the evidence in support of these theoretical explanations. The findings from this review can also guide the development and evaluation of interventions promoting maintenance of health behaviours and help in the development of an integrated theory of behaviour change maintenance.

**Keywords:** behaviour change; behaviour maintenance; theory; theory review

## **2.2 Introduction**

### **2.2.1 Importance of behaviour maintenance**

There is considerable evidence that behaviour can be influenced and changed effectively through behaviour change interventions (Albarracin et al., 2005; N. Hobbs et al., 2013). However, there is limited evidence for the sustainability of behaviour change in response to interventions (Avenell et al., 2004; Carpenter et al., 2013; S.U. Dombrowski et al., 2014; Fjeldsoe et al., 2011). This is partly because few studies evaluate long term effects and partly because there is evidence of intervention effects diminishing within a year (Curioni & Lourenco, 2005; S. U. Dombrowski, Avenell, & Sniehotta, 2010).

Initial rates of positive changes in health-related behaviours are much higher than the rates for people successfully maintaining new health behaviours. Relapse rates are high for people who join weight loss programmes (Tsai & Wadden, 2005); aim to stop smoking (Carpenter et al., 2013; Hughes, Keely, & Naud, 2004), drinking (Moos & Moos, 2006) or engaging in hazardous sexual behaviours (J. A. Kelly, Stlawrence, & Brasfield, 1991). Theories of behaviour change maintenance provide guidance for the development of interventions promoting sustainable change in health behaviours.

### **2.2.2 Theory of behaviour change maintenance**

A theory is a set of statements that organises, predicts and explains observations; it defines how phenomena relate to each other, and what can be expected under still unknown conditions (S. Bem & Looren de Jong, 1997). Theory may be useful to inform studies that help to improve our understanding of sustained behaviour and to design and implement interventions to achieve behaviour change maintenance (Craig et al., 2008). Given the lack of success in maintaining behaviour change following initiation and the importance of theory in the development and evaluation of effective interventions, a more systematic understanding of theory-based maintenance explanation is needed.

To date there has been no comprehensive review or synthesis of theories to underpin behaviour change maintenance. The aim of this review was therefore to identify theoretical explanations for behaviour maintenance from behavioural theories and to examine the relationships between these explanations. Theories for

maintenance of any human behaviour were examined; however, particular interest was in the application of the findings to health behaviours.

## 2.3 Methods

### 2.3.1 Design

Systematic review of behaviour theories.

Table 1 gives a summary of methods further discussed in detail below.

Table 1: A summary of methods for the theory review

<b>A systematic review of behaviour theories – methods summary</b>	
<b>1. Theory identification</b>	From 3 data sources: 1. Systematic on-line database search (Ovid MEDLINE, Embase, PsycINFO) 2. 'Theory Project' list 3. Contact with 40 experts (25 responses)
<b>2. Inclusion/Exclusion</b>	Criteria and definition of terms
<b>3. Data Extraction</b>	Including: ID number; theory name, full reference; verbatim general statements about behaviour maintenance (direct quote) and explanations of behaviour maintenance (interpretation); intended theoretical application; specified population and/or behaviour
<b>4. Narrative data Synthesis</b>	A) Testable explanations for behaviour maintenance reviewed in included theories B) Generation of themes: testable explanations analysed and grouped into theory themes and subthemes C) Theory themes validated by 10 health psychologists
<b>5. Review writing</b>	Review structured around the themes; interconnections between the themes discussed

### 2.3.2 Theory identification

Theories were identified in three ways:

1. Systematic database searches were performed to identify theories which met the inclusion criteria (see below). Ovid MEDLINE, Embase and PsycINFO databases were searched using a comprehensive search strategy (Appendix A), a maintenance-relevant set of search terms included 'maintenance', 'behaviour maintenance', 'maintain', 'sustain', 'sustained behaviour', 'sustained change', 'habit', and 'maintenance stage' as well as appropriate synonyms, and American spellings, adjusted in accordance with the particular database. There was no time limit applied. The search was last updated on 1<sup>st</sup> March 2014.
2. Eighty theories from a systematic review of behaviour change theories across psychology, sociology, anthropology, and economics were reviewed for inclusion (Michie, Campbell, Brown, & West, 2014)<sup>1</sup>.
3. Forty behaviour change theory experts were contacted and asked to identify any theories relevant to behaviour change maintenance; experts were defined as theory authors or critics.

For each theory, key papers were identified based on relevance and citations (Appendix B).

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<sup>1</sup> The list of theories was based on a previous list provided on 9<sup>th</sup> February 2012 by the Theory Project Team; (final list of theories published here: Michie et al., 2014).

### 2.3.3 Inclusion/Exclusion criteria

*Inclusion criteria:* Theories published in any language before 1<sup>st</sup> March 2014 related to behaviour change maintenance based on the following operational definitions:

**Theory:** A set of concepts and/or statements with specification of how phenomena relate to each other. Theory provides an organising description of a system that accounts for what is known, and explains and predicts phenomena (taken from Michie et al., 2014).

**Behaviour:** Anything a person does in response to internal or external events. Overt action (motor or verbal) which is directly measurable; behaviours are physical events that occur in the body and are controlled by the brain (taken from Michie et al., 2014).

**Behaviour change maintenance:** The continuous performance of a behaviour following an initial behaviour change at a level that significantly differs from the baseline performance in the intended direction. While some authors have suggested time cut-offs for behaviour change and transition to behaviour change maintenance (Prochaska & Di Clemente, 1983; Prochaska, DiClemente, & Norcross, 1992), a time cut-offs were not indicated here, as they may vary depending on behaviour, context and individual factors.

*Exclusion criteria:* (a) Theories about animal behaviour; (b) theories exclusively based on research with animals; and (c) unpublished theories presented in dissertations and doctoral theses. Screening was conducted by two reviewers (DK



and SD). All cases where inclusion/exclusion was unclear were discussed within the research team.

#### **2.3.4 Data Extraction**

Each theory was allocated a unique ID (see Appendix B). The theory name and its full references were recorded. Initially, verbatim general statements about behaviour change maintenance and explanations of behaviour change maintenance based on interpretations of the theoretical statements were extracted from each theory using a standardised data extraction form. In addition, intended theoretical applications including behaviour, context or population specificity were extracted if stated. Theories were extracted by one reviewer (DK) and two other reviewers (FS and SD) independently extracted theory data from 10% of the included papers resulting in full agreement between the reviewers.

#### **2.3.5 Data Synthesis**

Explanatory hypotheses for behaviour change maintenance were initially extracted by one researcher (DK). The data synthesis team met regularly over 18 months to discuss each of the theories from the dataset and confirm the extracted theory statements (DK, SD, MW and FS). The data synthesis team consisted of authors with backgrounds in psychology and public health who have experience in researching and applying behavioural theories, and in systematic reviewing and qualitative synthesis. For each theory, hypotheses were extracted verbatim and these hypotheses were then interpreted and reformulated as explanatory hypotheses to answer the research question. The outcome of the meetings was a list of

summative explanatory hypotheses that explained behaviour change maintenance derived from all included theories.

Thematic theoretical analysis of the explanatory hypotheses was employed to synthesise the data and identify patterns of theoretical explanations (themes). The analysis followed a staged process including familiarisation with quotes and their interpretations, generating initial codes (specific theory themes and subthemes), assessing themes among codes (overlapping characteristics), reviewing themes (for both theory themes and subthemes), defining and naming themes, and producing a final report. After theory themes were generated overlaps and relationships between themes were analysed. Thematic analysis was used to generate a concise set of summative constructs and propositions about their role in the maintenance of behaviour change. These summative constructs represent broad themes based on commonalities between theoretical explanations in terms of constructs and assumed mechanisms. The theoretical propositions within each theme were further organised by subthemes.

The summative explanatory constructs (themes) and proposed relationships resulting from the synthesis of the data were subsequently cross-validated by ten health psychology researchers not familiar with the current theory review who evaluated the validity of themes allocating a randomly selected 10% of the total extracted theoretical statements to summative constructs; each researcher received a different set of theoretical statements (see Appendix C). They could allocate one statement to more than one theme. Agreement on allocation of

themes was calculated as Krippendorff's  $\alpha$  to check for inter-rater reliability (Krippendorff, 2012).

## **2.4 Results**

### **2.4.1 Overall results**

A total of 264 records were identified through the search strategy. After removal of duplicates, 171 records were screened; leaving 117 theories, of which 100 published theories met the inclusion criteria (see Figure 1 for PRISMA flow chart). Forty international theory experts were contacted, of whom 25 replied suggesting theories with relevant hypotheses for behaviour change maintenance. The most commonly suggested theories were: Transtheoretical Model of Change (n = 11) (Prochaska & Di Clemente, 1983; Prochaska et al., 1992); The Health Action Process Approach (HAPA) (n = 10) (Schwarzer, 1992, 2008); Social Cognitive Theory (n = 9) (A. Bandura, 1986); Marlatt's Relapse Prevention Theory (n = 9) (G. A. Marlatt & George, 1984; Witkiewitz & Marlatt, 2004); Rothman's Theory of Maintenance (n = 8) (A. J. Rothman, 2000; A.J. Rothman, Baldwin, & Hertel, 2004; A. J. Rothman, Sheeran, & Wood, 2009); Self-Determination Theory (n = 7) (Ryan & Deci, 2000) and habit theories (n = 6) (B. Verplanken & Aarts, 1999; B. Verplanken & Orbell, 2003).

Among the included theories, 73 were behaviour specific. Fifty-three out of the 73 behaviour specific theories explained health-related behaviours. Most of the health behaviour specific theories built upon other available theories and applied these to behaviour specific contexts. Twenty-six theories were behaviour specific and population specific; all population specific theories were also behaviour specific [for

instance A Behavioral Model of Patients Medication Adherence (De Bruin, Hosters, Van Den Borne, Kok, & Prins, 2005)].

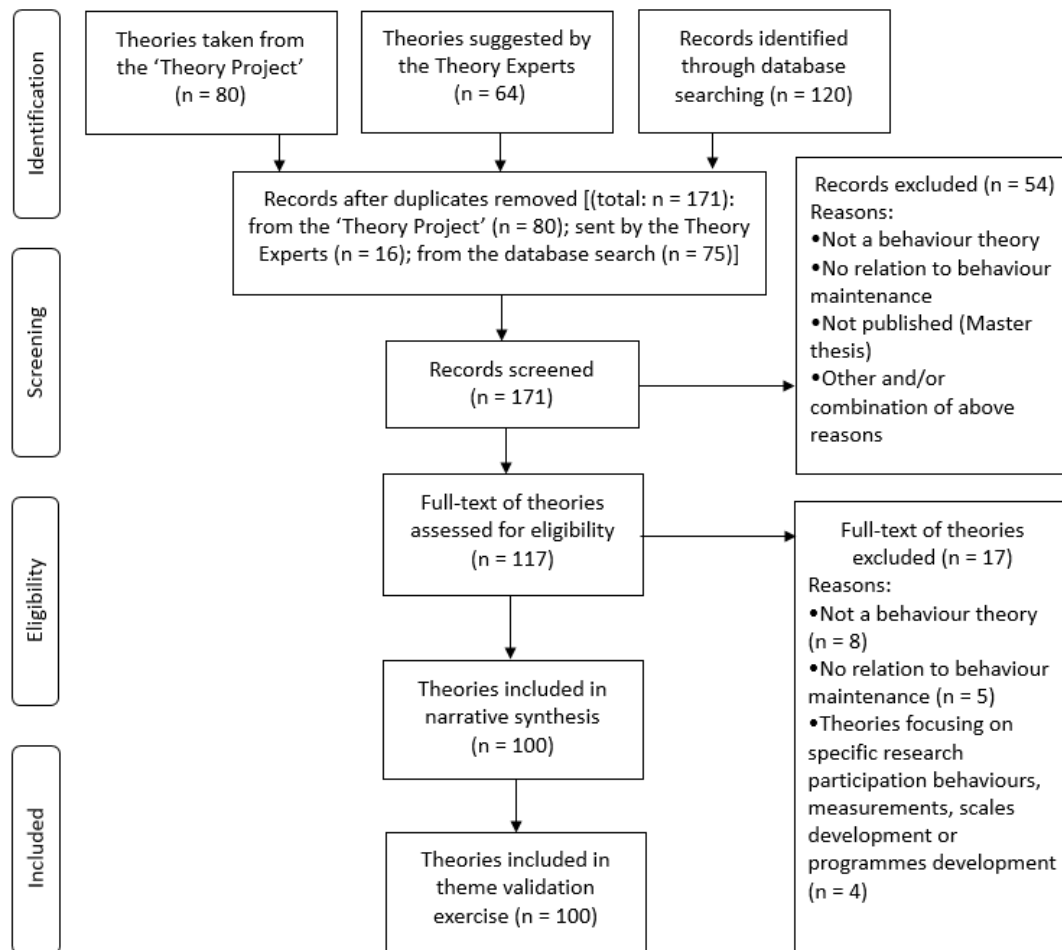


Figure 1: PRISMA 2009 flow diagram (Moher, Liberati, Tetzlaff, & Altman, 2009)

#### 2.4.2 How do theories explain behaviour change maintenance?

Many behavioural theories do not explicitly address the issue of behavioural maintenance. Forty-three included theories involved assumptions of dynamic reciprocity, meaning assumptions that explanatory variables are modified through exposure to the target behaviour. For example, social cognition models [e.g. Theory

of Planned Behavior (I. Ajzen, 1991)] hypothesise that behaviour is a function of cognitions about the desirability and controllability of behaviour. Maintained performance may lead to a re-evaluation of the behaviour and the individual may realise that it is less desirable or controllable than they perceived when they adopted the behaviour. While many theories suggest that maintained behaviour is explained within the same theoretical constructs as behaviour initiation, the content (e.g., self-efficacy), direction and value of the constructs may change substantially from initiation to maintenance.

Ecological models of behaviour offer the same nature of explanations for behaviour initiation and behaviour maintenance [e.g. Ecological Systems Theory (Bronfenbrenner, 1977, 1986), Ecological Model of Health Behaviours (McLeroy, Bibeau, Steckler, & Glanz, 1988), Social Ecology Model of Behaviour Change (Panter-Brick, Clarke, Lomas, Pinder, & Lindsay, 2006)]. In ecological models, behaviour typically is determined by hierarchically embedded systems and factors. Individual factors include skills, attitudes, knowledge and intentions, all of which influence behaviour initiation and maintenance. Interpersonal factors deal with immediate relationships which are essential components of social identity, which is shaped by social norms; the immediate social environment can serve to encourage, support and maintain desirable healthy behaviour [Ecological Model of Health Behaviours (McLeroy et al., 1988); Family System Theory (Bowen, 1966)]. Subsequently, behaviour initiation and maintenance are influenced by organisational, community and public policy factors, all of which have the potential

to provide support for behaviour changes, particularly if the new behaviour is a group or community norm or if a new behaviour is regulated by a newly-implemented policy.

For the remaining theories where differential explanatory hypotheses for initiation and maintenance could be derived, theory-guided thematic analysis resulted in five overarching interrelated themes (Table 2). These themes were cross-validated by 10 health psychology researchers, whose independent assessments resulted in a high level of agreement (Krippendorff's  $\alpha = 0.87$ ). The five themes reflect maintenance-specific theoretical explanations about how individuals maintain initial behaviour changes over time and in different contexts. Themes focus on the changing roles of motives, self-regulation, resources, habits, and contextual factors from initial behaviour change to successful maintenance. Explanatory hypotheses for behaviour change maintenance are described for each theme, followed by specific examples taken from individual theories.

Table 2: Main theoretical themes identified in the review

<b>Theme</b>	<b>Brief theoretical explanation</b>	<b>Theory examples</b>
(1) <b>Maintenance motives</b>	People tend to maintain their behaviour if they have at least one sustained motive, i.e. they are self-determined; satisfied with behavioural outcomes; they enjoy engaging in the behaviour; if behaviour is congruent with their identity, beliefs and values.	<ul style="list-style-type: none"> <li>- Model of Behaviour Maintenance (Rothman, 2000) changed into A 2 x 2 Behaviour Change Matrix (Rothman, Sheeran &amp; Wood, 2009)</li> <li>- Regulatory Fit Theory (Higgins, 2006)</li> <li>- Self-Determination Theory (Deci &amp; Ryan, 1985; 2008)</li> </ul>
(2) <b>Self-regulation</b>	People tend to maintain behaviour if they successfully monitor and regulate the newly adopted behaviour and have effective strategies to overcome barriers to the performance of the new behaviour.	<ul style="list-style-type: none"> <li>- Self-Regulation Theory (Kanfer &amp; Gaelick, 1991)</li> <li>- Relapse Prevention Theory (Marlatt &amp; Donovan, 2005)</li> <li>- Dual process model of self-control (Hofmann et al., 2008)</li> </ul>
(3) <b>Resources</b>	People are successful in maintaining behaviour if their psychological and physical resources are plentiful.	<ul style="list-style-type: none"> <li>- Reflective and Impulsive Model (Strack &amp; Deutsch, 2004)</li> <li>- Self-Control Theory (Muraven &amp; Baumeister, 2000; Baumeister, 2002)</li> <li>- Goal Conflict Model (Stroebe et al., 2008)</li> </ul>
(4) <b>Habit</b>	People are effective with maintaining behaviours which have become habitual and are supported by automatic responses to relevant cues.	<ul style="list-style-type: none"> <li>- Health-related model of behaviour change (Hunt &amp; Martin, 1988)</li> <li>- Habit Theory (Verplanken &amp; Aarts, 1999; Verplanken &amp; Orbell, 2003; Verplanken et al., 2008)</li> <li>- Process Model of Lifestyle Behaviour Change (Greaves, 2012)</li> </ul>
(5) <b>Environmental and social influences</b>	A supportive environment and social support are important for behaviour maintenance. People tend to maintain behaviour which is in line with relevant social changes.	<ul style="list-style-type: none"> <li>- Social Cognitive/Learning Theory (Bandura, 1989)</li> <li>- Social Change Theory (Thompson &amp; Kinne, 1990)</li> <li>- Normalisation Process Theory (May et al., 2007)</li> </ul>

### **2.4.3 Theme 1: Maintenance motives**

Motives are reasons why people engage in a given behaviour. Motives for initiating behaviour change may differ from those sustaining a newly adopted behaviour. The process of initial change is associated with regular reinforcement. Individuals experience regular positive changes associated with their behaviour change (e.g., they lose weight, and improve their fitness in a lifestyle change programme) and supportive social responses to the ongoing change. Regular attainment of personal change goals provides a sense of control and is a strong reinforcer (A. Bandura & Cervone, 1983). Maintenance, in contrast, is characterised by the absence of change. This may alter the salience and personal relevance of motives initially driving change and the appreciation of reinforcement associated with the initial change. Four key motives hypothesised to motivate behaviour change maintenance, as opposed to behaviour initiation, are: self-determination; satisfaction with behavioural outcomes; behaviour enjoyment and congruence of the newly adopted behaviour with identity, beliefs and values.

#### **2.4.3.1 *Self-determination***

If new behaviour is underpinned by internal motivation, a person is more likely to maintain the behaviour. During the behaviour maintenance process intrinsic motivation (i.e. the person wanting to maintain the new behaviour) has a stronger influence on behaviour than extrinsic motivation (i.e. other people put pressure or provide incentive to maintain behaviour). Internal autonomous motivation guides long-term sustained change [Self-Determination Theory (E. L. Deci & Ryan, 2000;



Ryan & Deci, 2000)]. Extrinsic motivation can support behaviour change, but change is more likely to be sustained when new behaviours resemble individuals' values and are perceived as personally important.

#### **2.4.3.2 *Satisfaction with outcomes***

Behaviour initiation depends on favourable expectation of future outcomes whereas behaviour maintenance depends on perceived satisfaction with received outcomes [Model of Behaviour Maintenance (A. J. Rothman, 2000; A.J. Rothman et al., 2004)]. Cognitive assessment and evaluation of behaviour outcomes underlines behaviour maintenance [A Behavioral Model of Medication Adherence (De Bruin et al., 2005)]. Suggested interventions relating to satisfaction with behaviour outcomes that can boost behaviour change maintenance include: temporal comparisons, making people mindful of behaviour change, and shifting expectations [2x2 Behaviour Change Matrix (A. J. Rothman et al., 2009)]

#### **2.4.3.3 *Enjoyment of behaviour***

Affective rather than cognitive beliefs about behaviour are more predictive for sustained performance. Behaviour is more likely to be sustained if the reinforcement structure emphasises immediate and affective consequences rather than long-term cognitive outcomes. Immediate and affective outcomes are more likely to lead to sustained changes rather than rational and long-term consequences [Temporal Self-Regulation Theory (P.A. Hall & Fong, 2007)]. An absence of enjoyment is theorised as a main reason for being unable to maintain behaviour [Groningen Active Living Model (M. Stevens, Bult, de Greef, Lemmink, & Rispens,

1999)]. Motivation to avoid negative health consequences is hypothesised to be insufficient to maintain preventive behaviour that requires maintained effort, therefore positive motives are needed [Precaution Adoption Process Model (Weinstein, 1988; Weinstein & Sandman, 1992)]. People engage more strongly in what they are doing if they 'feel right about it' and if it fits with their decisions and prior engagements [Regulatory Fit Theory (E.T. Higgins, 2006)]. Enjoyment of a behaviour and a health-related goal can be in conflict [Goal Conflict Model (Stroebe et al., 2008)]. Nature and timing of anticipated and experienced consequences impact on behaviour change maintenance.

#### **2.4.3.4 Identity**

Self-perception is hypothesised to determine behaviour change maintenance. People predominantly maintain behaviours which are in line with the beliefs they have about themselves [Self-Schema Theory (Markus, 1977); Self-Concept Theory (Bracken, 1996)]. These beliefs guide behaviour maintenance as they lead and organise the processing of self-relevant information. For instance, a person who exercises regularly can develop the self-representation of being a sportsperson which positively enhances behaviour maintenance. People more easily maintain behaviour change if it fits in with their self-representation, beliefs, values and attitudes. Self-identity and nested values and beliefs can change as a result of sustained behaviour change.

Initial behaviour change that is triggered by a significant life event/crisis can cause a shift in a person's identity [Process of Reinvention Theory (Epiphaniou & Ogden,

2010; Ogden & Hills, 2008)] and such event-triggered changes are hypothesised to be particularly sustainable. A life event/crisis usually relates to relationships, health, or other life events judged to be significant. Behaviour change is often maintained after a life crisis if the person no longer perceives themselves to benefit from a particular behaviour; if there are fewer opportunities to perform a behaviour; or if they believe that the behaviour was the cause of the crisis. People experience shifts in their beliefs, followed by identity changes which support behaviour change maintenance.

Congruence with identity is a key feature of the behaviour internalisation processes, behavioural regulation and long-term health behaviour change maintenance [Health Behavior Internalization Model (Bellg, 2003)]. Internalisation is the learning of values or attitudes. Self-needs (i.e. identity, self-determination, security and support) and behaviour-related needs (i.e. preference, context competence and coping) interact and influence internalisation and self-regulation of the new health-related behaviour leading to health behaviour maintenance. A shift in self-perception is theorised as a prominent factor in behaviour change maintenance; people are biased to self-regulate their behaviour in line with their self-concept.

In summary, behaviour is more likely to be maintained if it is in line with intrinsic as opposed to extrinsic motivation (E. L. Deci & Ryan, 2000; Ryan & Deci, 2000). People tend to maintain their behaviour if they are satisfied with behavioural outcomes and if this satisfaction is sustained (De Bruin et al., 2005; A. J. Rothman,

2000; A.J. Rothman et al., 2004; A. J. Rothman et al., 2009). People are likely to maintain behaviour which is enjoyable (P.A. Hall & Fong, 2007; E.T. Higgins, 2006; M. Stevens et al., 1999; Weinstein, 1988; Weinstein & Sandman, 1992) and which is in line with their identity (Bracken, 1996; Markus, 1977). Significant life events are theorised to cause shifts in identity which may lead to sustained behaviour change (Epiphanou & Ogden, 2010; Ogden & Hills, 2008). The behaviour internalisation process involves identity adjustment which leads to behaviour maintenance (Bellg, 2003). People need a sustained motivator in order to maintain new behaviour and these sustained motivators may differ from those underlying the initial change process.

#### **2.4.4 Theme 2. Self-regulation**

Self-regulation is the ability to actively control behaviour; aptitude to override or inhibit dominant and often automatic behaviours, urges, emotions or desires that would otherwise hinder goal-directed behaviour (Baumeister, Heatherton, & Tice, 1994). Self-regulation includes processes of self-monitoring, self-evaluation and self-reinforcement (F. H. Kanfer & Karoly, 1972) as well as dealing with temptations, hedonistic and impulsive influences which are in conflict with an individual's long-term goals. There are explicit maintenance relevant theories which emphasise the role of active self-regulation on the behaviour maintenance process. Behavioural processes associated with self-regulation which underpin maintained behaviour are self-monitoring and self-evaluation, sustained commitment to the goal, and coping with behavioural barriers, overcoming obstacles and preventing relapse.

#### **2.4.4.1 Self-monitoring and self-evaluation**

People have different levels of ability to self-control their actions; called self-regulatory capacity [Temporal Self-Regulation Theory (P.A. Hall & Fong, 2007)]. Individual differences in self-regulatory capacity predict intention-behaviour correspondence with those lower in self-regulatory capacity showing weaker intention-behaviour relationships (P. A. Hall, Fong, Epp, & Elias, 2008). Self-regulatory strength is considered more important during behaviour initiation than during behaviour maintenance [2x2 Behaviour Change Matrix (A. J. Rothman et al., 2009)] because during behaviour maintenance the new pattern of behaviour becomes the dominant response and less cognitive resources are used to perform and regulate the behaviour.

Behaviour maintenance is theorised as an outcome of active and on-going self-regulation. The process of self-regulation is based on a system of hierarchically organised goals. Individuals monitor their behaviour against their goals and adapt their efforts if they perceive discrepancy between the current and a desired state [Control Theory (Carver & Scheier, 1982)]. If a discrepancy is not detected or if behaviour exceeds standards, the person will feel satisfied and will not be motivated to change [Self-Regulation Theory (F.H. Kanfer & Gaelick-Buys, 1991)]. Behaviour that falls short of relevant goals causes dissatisfaction and leads the individual to attempt a new behaviour that is more consistent with the goals.

#### **2.4.4.2 Sustained commitment to the goal**

Behaviour maintenance has been linked to goal-directed self-regulation. Challenging goals may result in better performance as they allow people to attribute intermediate failure to the difficulty of the goal, whereas failure with regard to simple goals implies a lack of capability resulting in lowered self-efficacy [Social Learning Theory (Bandura, 1977)]. Goal achievement involves appraisals, motivation and emotional reactions and coping responses [Goal Theory (Bagozzi, 1992)]. Goals that are highly valued are assumed to have a greater influence on behaviour than less valued goals [Health Behaviour Goal Model (Gebhardt, 1997; Jessor & Jessor, 1977)]. Sustained commitment to the goal directly relates to behaviour maintenance, especially when goals are difficult and when they require effort [Goal Setting Theory (Locke & Latham, 2002)]. People with challenging goals may achieve more because they are dissatisfied with lower standards and their satisfaction level is demandingly high (Locke & Latham, 2002), although the generalisability of this proposal is unclear (R. Crawford & Glover, 2012).

#### **2.4.4.3 Lapse, relapse and coping with behavioural barriers**

Self-regulation involves coping with behavioural barriers, overcoming temptations, managing lapses and avoiding relapse. A lapse is one singular event in which a person deviates from their desired goal; (e.g. a cigarette smoked during an abstinence attempt or a high calorie snack eaten while on a weight loss diet). A relapse is a sequence of lapses strung together. Relapse is defined as a setback that occurs during the behaviour change process; it is an interruption of behaviour

initiation or behaviour maintenance that causes reversion to the previous behaviour (e.g. regular smoking, overeating) (Witkiewitz & Marlatt, 2004). Relapse prevention theory commonly includes several variables that directly influence behaviour maintenance, but not necessarily behaviour initiation, including interpersonal stress, cravings, mood, self-efficacy and other distal risk factors (Hendershot, Witkiewitz, George, & Marlatt, 2011).

In response to situations with a high risk of lapse or relapse, people may apply effective coping responses and as a result their self-efficacy and positive outcome expectancies increase and the probability of future relapse decreases [Relapse Prevention Theory (G. A. Marlatt & George, 1984)]. Nevertheless, people may fail to apply effective coping responses in high risk situations and as a result their self-efficacy and positive outcome expectancies decrease; then people often return to the initial unhealthy behaviour and their probability of future relapse increases (G. A. Marlatt & George, 1984).

In order to maintain a behaviour, a person needs to maintain high self-efficacy levels (coping self-efficacy), which involves positive beliefs about their capability to overcome barriers to behaviour maintenance [HAPA (Schwarzer, 1992, 2008)]. Adherence to a new health behaviour may be challenging, but a person with a high level of self-efficacy responds confidently to behavioural barriers with effective behaviour maintenance strategies (i.e. action planning and coping planning), with sustained effort and with prolonged persistence. Recovery self-efficacy, on the other hand, addresses the experience of failure followed by the recovery from a

setback (Schwarzer, 2008). In coping planning (Sniehotta, Schwarzer, Scholz, & Schuz, 2005), people benefit from successful confrontations with high risk situations. During coping planning people plan strategies to overcome anticipated barriers to behaviour change. Action planning (Gollwitzer, 1999) is considered to be more important during behaviour initiation, whereas coping planning is crucial during behaviour maintenance (Sniehotta et al., 2005).

In summary, according to several behaviour theories the ability to successfully self-regulate behaviour underpins behaviour change initiation. In other theories, however, self-regulation is still important during behaviour maintenance and people need to focus on self-regulation to maintain a new behaviour (Carver & Scheier, 1982; F.H. Kanfer & Gaelick-Buys, 1991). Sustained commitment to the goal leads to behaviour maintenance (Locke & Latham, 2002). Theories of relapse prevention (Hendershot et al., 2011; G. A. Marlatt & George, 1984; Witkiewitz & Marlatt, 2004) and coping with situational barriers (Schwarzer, 1992, 2008; Sniehotta et al., 2005) suggest that the ability to successfully overcome relapse and high coping planning self-efficacy supports maintained behaviour change.

#### **2.4.5 Theme 3. Resources**

Since maintaining initial behaviour change is often difficult and requires sustained efforts, individual resources are hypothesised to play a major role in maintaining behaviour. Resources are defined as psychological and physical assets that can be drawn on in the process of behavioural regulation. Various conditions can hinder behaviour change maintenance, including ego depletion (Collins & Lapp, 1992), high



cognitive load (Frieese, Hofmann, & Wanke, 2008), low working memory capacity (Fletcher, Marks, & Hine, 2011), and influence of alcohol and other substances (Gunn, Finn, Endres, Gerst, & Spinola, 2013). This section addresses self-regulation as a limited resource, inter-individual differences in cognitive resources and resource availability.

#### ***2.4.5.1 Self-regulation as a limited resource***

Self-regulation draws on finite mental resources which become depleted through the use of self-regulatory processes and take time to rest and recover [Strength Model of Self-Control (Baumeister, 2003; Muraven & Baumeister, 2000); (M. S. Hagger, Wood, Stiff, & Chatzisarantis, 2009)]. Coping with stress, resisting temptations, and controlling emotions requires additional self-regulatory efforts and each additional attempt to self-regulate is more likely to fail. When cognitive resources are limited, people who are actively self-regulating are prone to engage in impulsive or automatic behaviours which often reflect habitual behaviour before people have made initial changes [Strength Model of Self-Control (Baumeister, 2002, 2003; Baumeister & Heatherton, 1996)]. For instance, dieters are vulnerable to uncontrolled eating when cognitive processes are disrupted [Dietary Restraint Theory (Polivy & Herman, 1985)]. People who actively restrain from unhealthy behaviour are more likely to engage in the given behaviour under these conditions than people who are not actively regulating; this phenomenon is explained in terms of goal accessibility and primed enjoyment [Goal Conflict Model (Stroebe et al., 2008)].

#### **2.4.5.2 *Inter-individual differences in resources***

Behaviour is governed by the interplay of two regulatory systems, a reflective system, which is based on conscious deliberation, controlled, but effortful, which aims to override a quicker automatic system which responds in line with habits [Dual-system Models (Metcalf & Mischel, 1999; Strack & Deutsch, 2004)]. In order to override the automatic system, resources are required. If these are not present, then the automatic system overrides the reflective one, which often leads to maintenance failure. There are stable inter-individual differences in executive control, e.g., the ability to override automated responses (Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Dispositional or situational moderators shift the weight between impulsive and reflective influences [Impulsive versus Reflective Framework (Hofmann, Friese, & Wiers, 2008)]. Restrained cognitive resources paired with unconscious positive expectations towards unhealthy behaviour may hinder behaviour change maintenance.

#### **2.4.5.3 *Availability of resources***

There are age-related changes that occur in the availability and efficiency of human resources [Selection, Optimisation and Compensation model (Baltes, 1997)]. Throughout life, social and individual possibilities change and people develop, elaborate and commit to personal goals in the goal selection process. Goal selection can be elective or responsive to experienced loss of resources. During elective goal selection people define their goals in order to match their personal needs and motives. Loss-based goal selection is a response to the loss of previously available

resources. Optimisation refers to achieving desired outcomes in selected domains; it requires acquiring, applying and refining goal-directed means. People adjust their goals to focus or redirect their efforts to maintain functioning or they substitute for a functional loss via compensation.

In summary, many behavioural theories that address the role of resources in behaviour maintenance processes describe self-regulation as a limited cognitive resource (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister & Heatherton, 1996; Baumeister et al., 1994; Baumeister, Muraven, & Tice, 2000); compare impulsive versus reflective influences on behaviour (Metcalfe & Mischel, 1999; Strack & Deutsch, 2004) and investigate restraint behaviours (Polivy & Herman, 1985; Stroebe et al., 2008). The Selection, Optimisation and Compensation model (Baltes, 1997) provides a broad account of behaviour change maintenance in the face of limited resources over the life-course.

#### **2.4.6 Theme 4. Habit**

Habits are behavioural patterns, based on cue-behaviour associations that are learned through repetition in similar context (B. Verplanken, 2006). They are elicited automatically when associated cues are encountered (P. Lally, Van Jaarsveld, Potts, & Wardle, 2010). Even when cognitive resources are limited, people are still quite effective at maintaining behaviours that are habitual and automatic. In the context of positive health-related behaviours such as running, taking medication, eating fruit and vegetables, habits are desirable; however this is not so for harmful behaviours such as sedentary behaviour, smoking, or drinking

alcohol. Habits are included in general theoretical frameworks such as dual process models (Metcalfe & Mischel, 1999; Strack & Deutsch, 2004) as well as specific theories of habit development, maintenance and breaking habits, which provide insight into behaviour change maintenance.

#### ***2.4.6.1 Dual process models and habit theories***

Individuals can maintain behaviour through ongoing self-regulation; however, self-regulation draws on finite psychological resources which can be depleted. When resources are low self-regulation is likely to fail. Thus, the most sustainable mechanism for maintenance is to develop automaticity for the newly adopted behaviour [Dual-system Models (Metcalfe & Mischel, 1999; Strack & Deutsch, 2004)]. Behaviour is a function of reflective and automatic processes [Theory of Interpersonal Behaviour (Triandis, 1977); Health-related Model of Behaviour Change (Hunt & Martin, 1988); 2x2 Behaviour Change Matrix (A. J. Rothman et al., 2009)]. Higher levels of cognitive processing are usually not necessary when activities become habitual.

Habitual behaviours are carried out with minimum awareness while conscious behaviours are performed less regularly. Relegation of habits to lower levels of consciousness is seen as part of the human adaptation process. Individuals are able to deal with a large number of internal and external stimuli because habitual behaviours require minimum levels of awareness and resources. Higher level self-regulation, decision making and monitoring processes can then deal with more novel features of the environment. Habit facilitates behaviour change maintenance

as desired activities become habitual, taking place outside of conscious awareness [Habit Theory (B. Verplanken & Aarts, 1999)]. Reflective and automatic influences are altered by boundary conditions (i.e. habitualness, ego depletion [Impulsive versus Reflective Framework (Hofmann et al., 2008)]).

#### **2.4.6.2 Learning theories and habit**

In learning theories, repetition and reinforcement are considered as a key to habit formation [Classical Conditioning (Pavlov, 1927) and Operant Conditioning (Skinner, 1953); Pavlovian Instrumental Transfer (J. Hall, Parkinson, Connor, Dickinson, & Everitt, 2001); Two-Factor Avoidance Theory (Stasiewicz & Maisto, 1993) and Associative Theories of Goal-directed Behaviour (de Wit & Dickinson, 2009)]. Behaviour change maintenance is promoted by a number of factors such as situating new learning in the most relevant contexts, providing retrieval cues after the new learning is complete, and varying the contexts in which the new learning takes place [A Learning Theory Perspective on the Maintenance of Behaviour Change (Bouton, 2000)]. Learning theories provide a wide range of explanations for how new behaviours are acquired and how they become habitual.

In order to maintain behaviour it is hypothesised that it is beneficial for people to be conditioned to certain behavioural responses occurring in a given situational context. For new conditioned reflexes to be established, any external stimulus (which will become the signal in a conditioned reflex) must overlap in time with the action of an unconditioned stimulus [Classical Conditioning (Pavlov, 1927)]. After repeated association of a stimulus and behavioural response, maintenance of

behaviour develops. Individuals can be conditioned to perform new behaviours if stimuli and behavioural response become associated; to break an existing association, stimuli and response must be disassociated [Classical Conditioning (Pavlov, 1927); Operant Conditioning (Skinner, 1953)]. For instance when individuals adopt a new, healthy diet, they are conditioned to certain stimuli, (e.g. lunch time) which produces a situational response (e.g. consuming a salad). Repeated association of stimuli and response leads to behaviour change maintenance. Unlearning or dissociation is a slow process and in some cases does not occur for behaviours which are engrained and thus still remain response options even after many years of not practicing them.

In summary, common features of habit theories are: automaticity of behaviour; situation or cue dependence; learning via repetition. Dual-processing explains the interaction between conscious and automatic aspects of behaviour (Metcalfe & Mischel, 1999; Strack & Deutsch, 2004). In behaviour change maintenance processes, behaviour is often habitual (Hofmann et al., 2008; Hunt & Martin, 1988; A. J. Rothman et al., 2009; B. Verplanken & Aarts, 1999). Habit theories are often contrasted with theories of deliberate action. Learning theories provide an explanation for the development of habits as well as a model for the influence of environmental forces on behaviour.

#### **2.4.7 Theme 5. Environment and social influences**

Whereas the previous four themes referred directly to the individual, this last theme includes a person's external context. Environment is defined broadly as the

setting or conditions in which a particular activity is carried out. Many theories emphasise the role of a supportive external environment on behaviour change maintenance, and most ecological models of behaviour suggest equal explanations for behaviour initiation and maintenance (Bronfenbrenner, 1977, 1986; McLeroy et al., 1988; Panter-Brick et al., 2006). In some theories, a supportive environment is more important for maintaining than for initiating new behaviour (e.g. in the aforementioned habit theories). Supportive environment, positive social influences and constructive social change facilitate the maintenance of behaviour change.

#### **2.4.7.1 Environment**

In the equal explanations theories, behaviour maintenance is influenced by multiple systems, all nested within each other; to understand behaviour change maintenance, all the systems need to be taken into consideration. In contrast, for some theories a supportive environment is more important during behaviour maintenance than during behaviour initiation. People develop context-dependent associations which are easy to maintain in the same environment [In theories including habit component: Impulsive versus Reflective Framework; Process Model for Supporting Lifestyle Behaviour Change (C. Greaves, Reddy, & Sheppard, 2010); 2 x 2 Behaviour Change Matrix (A. J. Rothman et al., 2009); Habit Theory (B. Verplanken & Aarts, 1999)]. Habits are often cue driven and they emerge depending on the environment. If people change their context, they are more likely to perform non-habitual behaviour (B. Verplanken, Walker, Davis, & Jurasek, 2008). When the environment changes, a window of opportunity opens for habit change

[Habit Theory (B. Verplanken et al., 2008)]; whereas people are more likely to maintain habitual behaviours in stable contexts. Environmental changes provide a threat for positive behaviours but also opportunity for new healthy behaviours.

#### **2.4.7.2 Social influence**

Social influence occurs when a person's opinions, emotional states and behaviours are affected by other people. People acquire knowledge through the observation and replication of other peoples' actions, this process is called social modelling [Social Cognitive Theory (A. Bandura, 1986)]. People are more likely to follow the guidance given them by people they trust and they feel connected to, thus to maintain a new behaviour a sense of relatedness must be developed [Self-Determination Theory (E. L. Deci & Ryan, 2000; Ryan & Deci, 2000)]. People define themselves in terms of group membership and are motivated to evaluate their group positively, usually showing a preference for a group they belong to as compared to other groups [Social Identity Theory (Turner, 1987)]. Individuals attempt to achieve or to maintain positive social identity [Social Identity Model (Tajfel & Turner, 1979)]. People sustain actions which are in line with group norms and which are approved by group members [e.g. Substance Abuse Theory (Neff & MacMaster, 2005)]. People are biased towards their own social group; they tend to follow the social norms and rules of the group they belong to.

#### **2.4.7.3 Social change – how norms are shaped, accepted and maintained**

Social change often leads towards behaviour change maintenance. Large-scale behavioural change is best achieved by changing the standards of what is



acceptable in a given community [Social Change Theory (B. Thompson & Kinne, 1990)]. Social change has been described as a three step process: unfreezing, moving, and freezing [Theory of Change (Lewin, 1951)] or implementation, embedding and sustaining [Normalisation Process Theory (C. May & Finch, 2009; C. R. May et al., 2009)]. The process of freezing is equivalent to maintaining newly introduced behaviours, which have become social norms and which are accepted in the given context [Theory of Change (Lewin, 1951)]. 'Social habits' are socially accepted behaviours that are resistant to change; 'a quasi-stationary equilibrium state' is a stable yet susceptible to change state, which at the same time is underpinned by an on-going social process [Theory of Change (Lewin, 1951)]. Sustaining embedded practices in their social contexts, also called 'integration', is relevant to maintaining behaviours [Normalisation Process Theory (C. May & Finch, 2009; C. R. May et al., 2009)]. Through social change, practices can become routinely embedded in everyday life. For social change to be maintained, people should feel responsible for the programmes promoting change and they should take control over them so they continue to maintain them after initial organising efforts [Social Change Theory (B. Thompson & Kinne, 1990)].

In summary, a supportive environment facilitates behaviour change maintenance. In stable environments, people develop habits that are theorised to be easier to maintain than self-controlled reflective behaviours (Hofmann et al., 2008; Hunt & Martin, 1988; A. J. Rothman et al., 2009; B. Verplanken & Aarts, 1999). Social support plays a vital role in behaviour change maintenance (Neff & MacMaster,

2005; Tajfel & Turner, 1979; Turner, 1987). People more easily maintain behaviour which is in line with relevant social norms (Lewin, 1951; C. R. May et al., 2009; B. Thompson & Kinne, 1990). Theories of behaviour change emphasise that human context, including proximal environment, social influences and social changes, impacts on behaviour change maintenance.

## **2.5 Discussion**

### **2.5.1 Main findings**

By systematically reviewing maintenance-relevant behaviour change theories, five overarching interconnected theoretical themes emerged: maintenance motives, self-regulation, resources, habits, and contextual influences. Based on these themes, differential hypotheses for the initiation and successful maintenance of health-related behaviours have been formulated. In Figure 2 a graphical illustration of the systematic theory review findings is presented, integrating these theoretical themes, and summarising and simplifying described current theoretical concepts relevant for behaviour change maintenance.

Individuals need at least one sustained motivator to maintain behaviour; these may include self-determination, satisfaction with behavioural outcomes, behaviour enjoyment, or behavioural congruence with beliefs and values, all of which often develop after initiating a new behaviour. It is likely that individuals make behaviour change attempts at times when their motivation is at the highest and opportunity costs are low. As motivation and opportunity costs regress to the mean (i.e., as motivation decreases and costs increase), the need for self-regulatory effort is

increased in order to ensure that the new behaviour continues despite less than optimal conditions.

The ongoing and active use of limited cognitive self-regulatory resources can result in ego depletion, with stress, tiredness, substance use, and negative affect also leading to a decreased ability to exert control over, or self-regulate, behaviour. At different times and depending on the availability of cognitive resources, motivation, and level of depletion, behaviour change maintenance may alternate between needing to be actively self-regulated and being automatic, context-driven and effortless. With repeated performance of a new behaviour, the need for conscious self-regulation decreases and behaviour becomes habitual, which in turn increases the chance that it will be maintained.

Behaviour, whether under conscious control or occurring automatically and habitually, occurs within an environmental and social context, with such influences serving to either facilitate or hinder behaviour change maintenance. As with the initiation of behaviour change, stable contexts make behaviour and habits easier to sustain. Thus, ecological factors are important for both behaviour initiation and maintenance.

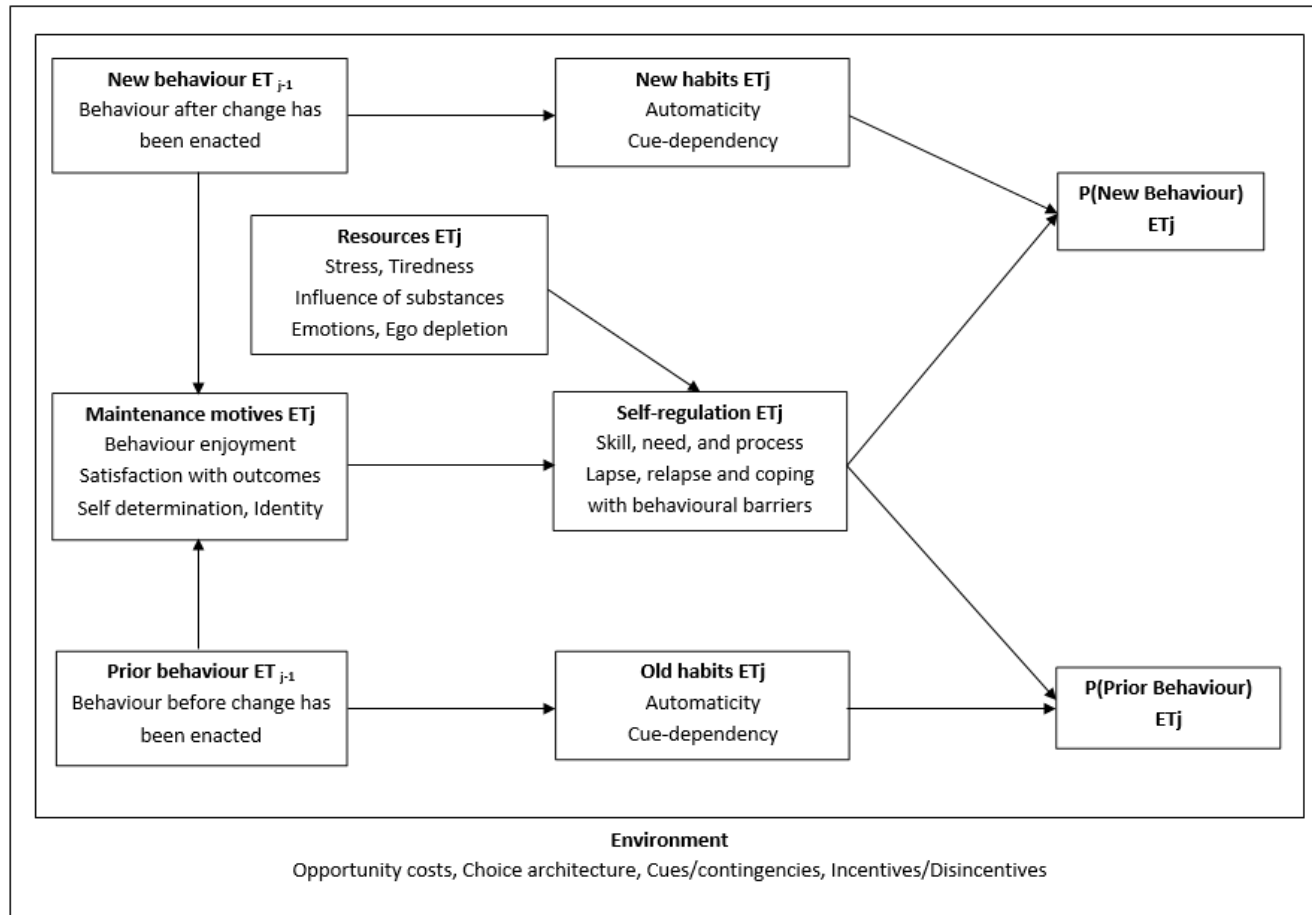


Figure 2: Themes derived from maintenance theories

### **2.5.2 Comparison with other studies**

This systematic theory review adds to existing knowledge of behaviour change maintenance by providing a comprehensive review of theories to identify the predictors that are relevant for maintained behaviour change. While previous reviews have focused on behaviour change (Cane, O'Connor, & Michie, 2012; Michie et al., 2005), this is the first review to specifically assess theoretical explanations for behaviour change maintenance. Overall, this review provides a summary of theoretical explanations for behaviour change maintenance; however, further research is needed to test the proposed relationships within and between the emerging themes.

### **2.5.3 Study strengths**

The main strength of this review is the comprehensive and rigorous search and the thematic theoretical synthesis of available theories addressing behaviour change maintenance. In this study, a new approach to theory analysis was presented, including identification of theoretical explanations and theory synthesis specifically in relation to behaviour change maintenance. This review not only identified themes that relate to behaviour change maintenance, but also resulted in the formulation of a number of theoretical predictions including the inter-relationships and dependencies between themes.

#### **2.5.4 Study limitations**

While the resulting summary provides a detailed description of broad themes and relationships relevant to maintenance, for a more detailed account of specific predictions, individual theories may be more relevant. This theory review drew mainly on theories which were designed and/or assessed in the context of health-related behaviours, and while the findings may be applicable to other contexts and behaviours, the degree of generalisability requires testing. While some theories have been assessed (M. S. Hagger et al., 2009; McEachan, Conner, Taylor, & Lawton, 2011), many theories lack systematic empirical evaluations. Similarly, the theoretical themes that emerged in this review will require further evaluation, development and testing (Sniehotta, Pesseau, & Araújo-Soares, in press).

#### **2.5.5 Unanswered questions and future research**

The main contribution of this review is the identification of the key hypotheses for behaviour change maintenance formulated in the theoretical literature to date. It provides a platform for future research and practice in behaviour change maintenance, which is a key priority area in behaviour change science. Future research should systematically review the existing evidence for each theoretical theme; and undertake further empirical testing of each explanation, followed by empirical testing of an integrated theoretical model. Evidence from theory-based interventions should be used to revise, refine, or reject theoretical principles (A. J. Rothman, 2004). Dialogue between theory and practice is encouraged so that theories are not only used to design interventions, but interventions also inform the

redevelopment of theories. Predictions and theoretical explanations should be tested across a variety of settings and populations, facilitating theory development. Future research should focus on the informed development of behaviour change maintenance theory, test themes presented within this review, explore relationships between themes and constructs, and add new theoretical predictions.

Health behaviour change studies have been synthesised across various health-related behaviours including preventing weight gain (Hardeman, Griffin, Johnston, Kinmonth, & Wareham, 2000); improving diet or encouraging physical activity (Abraham & Michie, 2008; S. Michie et al., 2011); smoking cessation (Michie, Hyder, Walia, & West, 2011); reducing alcohol intake (Michie et al., 2012); preventing HIV (Albarracin et al., 2005). The importance of having a theoretical basis for the design and evaluation of health interventions is well established (Craig et al., 2008). This includes providing a means of understanding why an intervention is effective or not. Effective BCTs are identified to distinguish active components of behaviour change interventions that lead to behaviour change maintenance (Michie & Johnston, 2012).

#### **2.5.6 Implications for health behaviour change maintenance**

The theoretical explanations described within the five overarching themes can be applied in health contexts to help explain maintenance of health-related behaviours. Listed theoretical explanations may be applied to facilitate interventions targeting health promotion and maintenance of health behaviours.

They can serve as guidance for intervention developers targeting five maintenance processes:

1. Helping individuals to maintain positive behaviour change maintenance motives, emphasizing positive outcomes of a new health behaviour, providing behavioural options which are enjoyable, inspiring individuals to redefine themselves in line with new healthy lifestyle principles.
2. Facilitating behaviour self-regulation; for instance through self-monitoring behaviour and helping individuals to develop effective strategies to overcome behavioural barriers and to prevent relapse.
3. Providing individuals with the resources needed to successfully maintain a new health behaviour. Resources can be physical (e.g., sport facilities, health products) or psychological (e.g., self-regulation training, mindfulness and relaxation methods).
4. Facilitating habit development and maintenance for positive health behaviour changes; for instance by reshaping the environment and making healthy options salient and by cuing individuals towards healthy behaviours.
5. Reshaping the environment at individual, societal and community levels. Providing social support and introducing social changes that are in line with positive health behaviour change maintenance.

## **2.6 Conclusions**

Specific theoretical explanations of behaviour change maintenance have been presented in this review. This review examined and summarised 100 theories that



explicitly or implicitly explain how individuals maintain new behaviours. Five theoretical themes included maintenance motives, active self-regulation, resources, habitual cue-driven responses, and environmental factors. This review therefore acts as a starting point on the journey towards an integrated behaviour change maintenance theory.

## **2.7 Link to other chapters**

This chapter summarised five main theoretical themes that emerged from the systematic review of behavioural theories. Following chapters provide empirical tests of theoretical predictions. In Chapter 3 theoretical predictions are tested within people through *N-of-1* study using time series analysis. In Chapter 5 theoretical predictions are assessed in data-prompted interviews and main themes are used as a theoretical framework for analysis of data. Allowing for framework flexibility and exploring new emerging themes, further predictions for behaviour change maintenance are explored.

## **2.8 Chapter acknowledgements**

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## **Chapter 3 N-of-1 study of weight loss maintenance in previously obese people assessing theory driven explanatory variables in relation to physical activity, plan adherence and weight.**

### **3.1 Abstract**

**Background:** Behaviour change interventions are effective in supporting individuals to achieve clinically significant weight loss, but weight loss maintenance (WLM) is less often attained or researched. There are explicit theoretical explanations for behaviour change maintenance that address the role of maintenance motives, self-regulation, resources, habits and contextual influences. This study aimed to advance understanding of explanatory variables associated with WLM within individuals.

**Methods:** *N*-of-1 design with daily measurement and time series analysis to explore WLM in 12 previously obese adults who lost over 5% of their body weight in the year prior to study enrolment. All participants completed the 2 months study period and 8 participants took part in the optional extension of the study to 6 months. Daily objective records of outcome variables weight and physical activity were collected alongside ecological momentary assessment (EMA) of self-reported outcome variable (adherence to WLM plan), as well as theory-based explanatory predictor variables; including maintenance motives, self-regulation, resources, habits and environmental/social influences.

**Findings:** For all 12 participants, daily fluctuations of the self-reported adherence to their WLM plan were significantly associated with the explanatory variables. Step count and weight were associated with adherence to the WLM plan. Patterns of variables contributing to the prediction and amount of variability accounted for, differed between participants for plan adherence and step count.

**Discussion:** Different maintenance-relevant variables were associated in different participants with ability to maintain weight, engage in physical activity and follow a personal WLM plan. Results suggest that personalised and stratified interventions are required to support individuals to maintain weight loss. The main study limitations were related to analytical challenges and the main strengths included novel method and technology used. This was the first study to assess theoretical predictions of WLM within individuals. Future research should further develop analytical approach to *N-of-1* for behavioural assessment, and explore the potential to intervene, in real-time, on the explanatory variables that significantly correlate with outcomes.

**Keywords:** behaviour change, *N-of-1*, theory, obesity, weight loss maintenance

## **3.2 Introduction**

### **3.2.1 Weight loss maintenance**

Worldwide obesity has nearly doubled since 1980; with 35% of the world's adult population being overweight, and of these 11% obese (World Health Organization, 2015d). In the UK the prevalence is much higher with 62% of adults being

overweight and 26% of these obese (Department of Health, 2011a). Obesity prevention and reduction programmes are high on the public health agenda in the UK, not least due to the direct obesity-related costs for the NHS being estimated to be about £5.1 billion per year (Department of Health, 2011b). Obesity has a significant impact on health and is associated with conditions such as type 2 diabetes, cardiovascular disease and cancer (Poirier et al., 2006). Weight loss over 5% of body weight is considered clinically significant, as it leads to clinically significant levels of health improvement (Franz et al., 2007). However, only a small number of people who initially lose significant amounts of body weight successfully maintain the new lower weight.

Public health interventions are generally effective in changing peoples' behaviours, often leading to clinically significant weight loss (S. U. Dombrowski et al., 2010; Jolly et al., 2011); however most weight loss is subsequently regained (Curioni & Lourenco, 2005). Systematic reviews of interventions promoting an increase in physical activity and a healthy diet have reported that, on average, half of the initial weight loss was regained after one year (Curioni & Lourenco, 2005). Another systematic review of the long-term effects of treatments for obesity reported that people regain a third of their initial weight loss within a year and the rest within 3-5 years (Avenell et al., 2004). A recent systematic review of WLM interventions shows that interventions focussing on dietary intake and physical activity are effective in slowing weight regain, but effects are modest and heterogeneous (S.U. Dombrowski et al., 2014). To date there is a lack of understanding of how best to

support individuals who have lost clinically significant levels of weight. This might be due to limited understanding of the behavioural processes underpinning WLM. A better theoretical understanding of behaviour change maintenance is desirable.

### **3.2.2 Assessing theory within individuals**

Previous studies assessing predictors of WLM and sustainable behaviour change employed between-subject designs (Svetkey et al., 2008; Wing & Phelan, 2005). However, the longer term individual weight management may involve critical intra-individual changes which might not be sufficiently captured by these designs. Periods of stable control of eating and sustained activity might be followed by temporal changes and lapses leading to a relapse. Many variables associated with healthy eating, being physically active and following a WLM plan, are theorised to vary within individuals. For instance the availability of cognitive resources has been theorised to explain the likelihood of engaging in healthy behaviours, i.e. people are less likely to perform health behaviours when they are tired, stressed, bored or when their attention span is limited (Hofmann et al., 2008). Thus, assessing within person differences has the potential to uncover important factors that impact on WLM.

Previous studies which have gathered daily data on cognitions commonly presented outcomes in the form of aggregated group scores which do not allow for within-person assessment of WLM predictions and outcomes (Carels, Douglass, Cacciapaglia, & O'Brien, 2004; Carels et al., 2002). The WLM-related cognitions such as resource indicators (e.g. attention span, stress, energy level) are often unstable

and tend to fluctuate (Hofmann et al., 2008). Therefore there is a need to appropriately assess variations of cognitions within the individual, using the most appropriate methods.

Within-person assessments of cognitions underlying health-related behaviours have more commonly been used in health psychology (Davidson, Peacock, Kronish, & Edmondson, 2014). The *N-of-1* design is a recommended method for testing behavioural theory within individuals through repeated measures over a period of time (Craig et al., 2008). The main features of *N-of-1* include the possibility to examine within-person variability in cognitions and outcomes, to test theory within individuals and to assess effects of BCTs within individuals (Johnston & Johnston, 2013). The *N-of-1* design has been successfully used in various settings and behaviours, including physical activity (Hobbs, Dixon, Johnston, & Howie, 2013; Sniehotta, Pesseau, Hobbs, & Araujo-Soares, 2012), and testing an integrated model of disability in individuals with chronic pain (Quinn, Johnston, & Johnston, 2013). To date none of the studies have examined variability in predictions of WLM behaviours in terms of day-to-day fluctuations.

### **3.2.3 The reported study**

This *N-of-1* study examined potential psychological predictors of WLM behaviours in individuals who have successfully lost clinically significant amounts of body weight. The aim was to explore associations between the theoretical predictions of WLM, with individual level behaviour related to WLM. In line with a systematic review of maintenance theories (Chapter 2) the maintenance relevant influences

were measured, including maintenance motives, self-regulation, resources, habits and environmental and social influences, to investigate their association with three outcomes: WLM plan adherence, physical activity and weight.

### 3.3 Methods

#### 3.3.1 Design

Observational *N*-of-1 design with self-report measures of WLM-relevant theoretical variables. Dependent variables were self-reported WLM plan adherence, and objectively measured step count and daily weight. Predictor variables were based on five theoretical themes. Table 3 gives a summary of methods.

Table 3: A summary of methods for the *N*-of-1 study

<b>Activity</b>	<b>Description</b>
Study recruitment	Via community groups and on-line; 15 people signed up, 12 were included
Ecologic momentary assessment	Twice a day (morning and evening) surveys designed in Qualtrics delivered to a mobile phone/ touchpad/ computer, as an automatic e-mail or text message, assessing cognitions and WLM plan adherence
PA monitoring	Wireless activity monitor (Fitbit THE ONE™) used daily to measure step count
Weight monitoring	Wi-Fi Scale (Fitbit's Aria™) used daily to measure weight
Proactive experience sampling	The functionality of the mobile phone was used to record notes and pictures; participants decided which experiences to capture and report on
Face-to-face interview	Each participant presented with the report including summaries of the data for the 2 months study period and then 6 months study period (8 out of 12 participants)

*Note.* Analysis and results of proactive experience sampling and face-to-face interviews are reported in Chapter 5.



### **3.3.2 Participants**

Participants were recruited based on study inclusion/exclusion criteria described below. The aim was to recruit between 5 and 10 individuals, in line with recommendations for the generalisability of *N-of-1* design (Duan, Kravitz, & Schmid, 2013) where the number of observations and not participants determines study power. Participants were recruited online via social media, using Facebook and Twitter, and through community advertisements using existing networks, mailing lists and engagement groups. Participants did not receive any financial reimbursement for their study participation and were offered travel expenses if required.

#### ***3.3.2.1 Study inclusion criteria***

Participants who intentionally lost over 5% of body weight in the previous year and who had a BMI of over 30 before weight loss, or 25 for participants from Asian background (Tan, 2004). Participation required access to a SmartPhone (e.g. iPhone, any Android phone, Blackberry), touchpad or computer with Internet connection, and a wireless internet access at home to connect the scales.

#### ***3.3.2.2 Study exclusion criteria***

Study exclusion criteria were: being pregnant or planning to be pregnant in the next 6 months; not willing to learn how to use a given study phone; not willing to use the phone regularly for study purposes; not having internet on the mobile

phone/touchpad/computer and not willing to accept a contract update; and having a pacemaker or other internal device preventing the use of wireless scales.

### **3.3.3 Study components and measures**

The study was divided into the following study components/activities:

#### **1. Ecological Momentary Assessment (EMA)**

EMA consisted of questionnaires which were sent to participants twice a day at times agreed with the participants to assess theory-driven predictors of WLM and WLM plan adherence (see Table 4 for the exact wording of all assessed items and mapping onto theoretical themes). For the morning assessment, participants were asked to specify any suitable time between 6am and 10am; for the evening assessment they were asked to specify any time between 6pm and 10pm. Questionnaires were delivered automatically via text or e-mail. All questions were answered on a 0-100 sliding visual analogue scale, apart from a question which assessed hours of sleep. Variables measured in the morning included views about WLM on that particular day: importance, motivation, confidence, and number of hours slept. Variables measured in the evening included retrospective feedback on the particular day: adherence to WLM plan, number of temptations, stress, energy levels, hunger, appreciation of weight loss benefits, social support, happiness, awareness, physical pain, obstacles, routines, typicality of the environment, personally relevant question (if participants felt that there was another important variable which had not been included in the question list e.g. *How much influence has your family had on your WLM plan today?*).

Table 4: Ecological Momentary Assessment questions and relevant themes

<b>Time</b>	<b>Question wording</b>	<b>Theme</b>
M	1. <i>How important is your weight loss maintenance plan compared to other things you want to do today? (0 – not important, 100 – very important)</i>	Motivation
M	2. <i>How motivated are you to follow your weight loss maintenance plan today? (0 – not motivated, 100 – very motivated)</i>	Motivation
M	3. <i>How confident are you that you can follow your weight loss maintenance plan today? (0 – not confident, 100 – very confident)</i>	Self-regulation
M	4. <i>How many hours of sleep did you have last night? (open ended question)</i>	Resources
E	1. <i>How much have you followed your weight maintenance plan today? (0 – not at all, 100 – completely)</i>	Outcome variable
E	2. <i>How tempted have you felt to break your weight maintenance plan today? (0 – very tempted, 100 – not tempted at all)</i>	Self-regulation
E	3. <i>How stressed have you felt today? (0 – very stressed, 100 – not stressed at all)</i>	Resources
E	4. <i>How energetic have you felt today? (0 –not energetic, 100 – very energetic)</i>	Resources
E	5. <i>How hungry have you felt today? (0 – very hungry, 100 – not hungry at all)</i>	Self-regulation
E	6. <i>How much have you appreciated the benefits of your weight loss today? (0 – not at all, 100 –all the time)</i>	Motivation
E	7. <i>How supported by other people in your weight maintenance plan have you felt today? (0 – not supported, 100 – very supported)</i>	Environment

E	8. <i>How happy have you felt today?</i> (0 – very unhappy, 100 - very happy)	Resources
E	9. <i>How aware were you of your weight maintenance plan today?</i> (0 – not at all, 100 – very aware)	Self-regulation
E	10. <i>How much physical pain have you felt today?</i> (0 – a lot, 100 – none) (this question depended on the prior study interview; participants could opt out from this question)	Other
E	11. <i>Have you experienced any significant obstacles to achieve your weight maintenance plan today?</i> (0 – a lot, 100 – none)	Self-regulation
E	12. <i>How much have you relied on your routines in your weight maintenance plan today?</i> (0 - not at all, 100 - a lot)	Habit
E	13. <i>How typical was your environment in relation to your weight maintenance plan today, e.g. access to food choices, physical activity opportunities?</i> (0 – as usual, 100 – very different)	Environment
E	14. Personally relevant question(s) – optional, were incorporated in the daily assessment, based on self-reported obstacles and factors that may impact on WLM.	Other
E	15. <i>Do you have any comments regarding your day today in relation with your weight maintenance plan?</i> (open ended question)	N/A

*Notes.* M – morning, E – evening question. Table shows how assessed variables fit into theoretical themes; however the distinction is only indicative as some variables could be assigned to more than one theoretical theme, e.g. hunger was assigned under the theme of self-regulation and dealing with obstacle: ‘feeling hungry’ but it could also be classified under the theme of resources.

Question order within each set (morning and evening set of questions) was randomised on a daily basis for each participant. Participants had an open box for comments at the end of all the questionnaires to provide optional feedback on anything that influenced their WLM on that day or on anything else that related to the study (e.g. *I forgot to wear my pedometer; I had a friend's birthday party so I did not comply with my plan*). Measures were based on theoretical predictions of behaviour maintenance (Chapter 2).

Measures were designed to capture day-to-day changes and intra-individual variability; they were all piloted for four weeks with a sample of four volunteers and all measures were reported as acceptable. Similar measures were also piloted and used in two ongoing *N-of-1* projects taking place in Newcastle University (McDonald, Hobbs, White, & Sniehotta, 2014; Newham, Pesseau, Araujo-Soares, & Sniehotta, 2014).

## **2. Measuring physical activity and weight**

To track activity and weight, for the study duration participants were given a wireless activity monitor (THE ONE™ - <https://www.fitbit.com/uk/one> Figure 3) and a wireless scale (Aria Scale™ - <https://www.fitbit.com/uk/aria> Figure 4). Participants were asked to wear the activity monitor daily, from when they woke up and left bed until they went to bed in the evening, and to weigh themselves once a day at a time pre-specified by them, preferably under similar circumstances (e.g. in the morning, before eating or drinking and dressed in underclothes only).



Figure 3: Activity monitor used in *N*-of-1 study - Fitbit THE ONE™



Figure 4: Wireless scale used in *N*-of-1 study - Fitbit Aria Scale™

Participants set up their on-line accounts for the devices and were free to monitor their progress and to access their own data at any time during the study. The outcome measured with the activity monitor was step count. Other activities (e.g. cycling), if self-reported in the Fitbit™ platform, were converted into the equivalent of steps and automatically added to the number of steps on the given day (using an algorithm embedded within the Fitbit™ platform). The device was worn in a stable

area of the trunk, i.e. on a belt, bra or in the pocket. The outcome measured daily with the wireless scale was weight; participants decided on their preferred weight unit: pounds, stones and pounds or kilograms.

### **3.3.4 Procedure**

The research was approved by the Newcastle University Ethics Committee (REC 00648\_1). The study took place in Newcastle-upon-Tyne (UK) between August 2013 and March 2014. Participants attended an introductory session with a researcher (DK). During the session participants' eligibility was assessed and the study explained in detail (Appendix D). All participants provided written informed consent (Appendix E).

First, participants were asked to describe how they typically maintain their weight loss and they specified what their WLM plan was. Participants clarified how active they typically are and what they typically eat on the days when they fully adhere to their WLM plan (100% adherence); this was a reference for their personal WLM adherence outcome. As each individual implemented their own WLM plan, each plan was subjectively different for each participant and was also likely to change over time. Then, participants decided on the specific timing for the EMA assessments; they were given a list of EMA questions and had an opportunity to familiarise themselves with questions and to clarify any items. In addition, participants could add up to three questions about person specific variable(s) which they felt had an impact on their WLM. Participants decided how they preferred to receive EMA questionnaires, e.g. via automated text message, or e-mail; they were

able to use a mobile phone, touchpad or computer with Internet connection to answer EMA questions.

Participants were given the equipment and were shown how to use it. Together with the session facilitator they formed action plans and coping plans to use the activity monitor and the scale daily. Action plans followed a standard format of specifying when, where and how equipment will be used; coping plans were based on barrier identification and forming plans for overcoming these barriers (Sniehotta et al., 2005). Participants were given the researcher's e-mail address and a study phone number which they were free to contact.

After the study set up, participants engaged in two study components as described above (EMA and measuring physical activity and weight). They were initially recruited for 2 months with the option to extend participation for up to 6 months. After 2 months they participated in a face-to-face interview session during which data patterns and personal accounts of WLM were discussed. The qualitative component of the study is described in Chapter 5. After 2 months participants could continue on the study for up to 6 months with an additional interview at the end.

### **3.3.5 Data analysis**

Data for each participant were analysed separately, i.e. each participant's data were treated as a separate data set. First missing data were imputed using bootstrapping methods with the *Amelia II* (<http://gking.harvard.edu/amelia>) with R package (Honaker & King, 2010); data were imputed separately for each data set



and for each data series<sup>2</sup> (the same procedures of dealing with missing data were applied by Nicola Hobbs et al., 2013; Quinn et al., 2013). For longer data series (more than 2 months) which showed a lower response rate towards the end of the series, e.g. five consecutive observations missing, and more than 25% of missing data per data unit (defined as 20 consecutive days) data series were shortened. For temporary long-term absence of data (e.g. two weeks of data missing due to holiday) before and after data series were combined. Less than 300 steps per day was considered as a missing value. SPSS version 21 was used for all further analyses (Hinton, McMurray, & Brownlow, 2014). Visual inspection of each data series was performed to inspect variability. Descriptive statistics for each data series within each data set were computed.

A pre-whitening procedure was applied as a process of removing autocorrelation<sup>3</sup> to ensure independence between data points. A procedure was performed on each data series with autocorrelation higher than 95% confidence intervals (to avoid type I error). Only autocorrelation at lag 1 and at lag 7 was controlled for, interpreted as day-to-day correlations and weekly cyclical patterns. The pre-whitening process was performed as follows: partial autocorrelation functions, which control for autocorrelation were examined in each series (i.e. each variable) and the lag at which the largest correlation occurred was identified for each series. A new, lagged, data series was then produced. For example, if the largest correlation occurred at

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<sup>2</sup> Data series is a sequence of data points, typically consisting of successive measurements made over a time interval, in this case for instance motivation measured every day.

<sup>3</sup> Autocorrelation is a correlation between the points of a series from the same series separated from them by a given interval (time lag).

lag 1 the new data series would be lagged by one time period relative to the original data series. This new lagged data series was then regressed onto the original series and the residuals saved. These residuals formed the pre-whitened data series used for subsequent analyses.

After autocorrelation had been controlled for, each participant series of independent variables was cross-correlated with plan adherence and with physical activity measure. The association between each independent variable and outcome variable was indicated by correlation coefficient function at time lag 0. Lag 0 being a correlation at the same time point, i.e. impact seen on the same day. Only cross-correlations that exceeded 95% CIs were considered predictive.

Sensitivity analysis was also performed for other time lags, studying the valence of correlation coefficient function at other time lags, indicating temporal relationships in which two observations occur. For instance, a positive lag suggests that the first variable precedes the second and negative lag suggests that the second variable precedes the first. For cross-correlations sensitivity analysis lag -1 (day before) and lag 1 (day after) were employed. The differences in outcomes between short (2 months) and long (up to 6 months) time series, before and after face-to-face interview, were also assessed.

## **3.4 Results**

### **3.4.1 Study participants and outcome variables**

A total of 15 people met the study inclusion criteria and were invited to take part in the study. Two people did not take part due to wireless internet connection problems and one person discontinued participation after losing the activity monitor and preferring not to use the scale. The final sample included 12 individuals whose characteristics are described in Table 5. The average age was 50.58 years (SD=9.92, and range 32-64).

Study participants were all previously obese; they had all lost at least 5% of their body weight and some had lost significantly more. At baseline some of the participants were still currently overweight (n=6) or obese (n=4), whereas others were now classified as normal weight (n=2) based on their BMI.

Table 5: Summary of participants' characteristics and outcome variables

P	Sex	Age in 2014	Weight at the start	Weight at 2 <sup>nd</sup> month	Weight at 6 <sup>th</sup> month	BMI at the start	BMI at 2 <sup>nd</sup> month	BMI at 6 <sup>th</sup> month	Adherence to the plan	Average step count
1	F	56	94.79	95.48	95.97	35.03	35.36	35.59	71.48 <sub>1</sub> (26.37)	4,473.23 <sub>1</sub> (3,699.53)
2	F	56	76.73	73.85	71.61	27.65	26.57	25.79	68.00 <sub>1</sub> (31.21)	10,617.00 <sub>1</sub> (3,653.77)
3	F	50	86.23	84.18	81.41	35.34	34.43	34.32	66.01 <sub>1</sub> (25.25)	10,611.26 (4,422.30)
4	F	45	63.54	65.05	60.45	22.54	23.13	23.58	63.72 <sub>1</sub> (13.98)	11,552.58 <sub>1</sub> (3,332.66)
5	M	32	89.46	88.74		26.99	26.94		57.80 <sub>7</sub> (17.59)	10,775.95 (4,173.87)
6	M	50	129.75	121.37	124.53	41.67	38.91	41.7	89.20 <sub>1</sub> (16.36)	8,025.84 (3,721.80)
7	F	37	82.46	80.60		26.48	25.87		66.1 (22.90)	6,769.12 (2,518.19)
8	M	61	86.11	84.90	77.79	25.49	25.11	24.77	86.89 (15.83)	10,055.63 <sub>7</sub> (5,153.19)
9	F	62	83.96	83.84		26.72	26.7		40.9 (20.67)	8,851.77 (548,81)
10	F	50	96.64	96.04	101.01	34.7	34.39	36.22	47.06 <sub>1</sub> (24.80)	7,477.56 (3,401.87)
11	F	64	72.70	76.01	73.47	25.86	27.03	27.78	51.46 <sub>1</sub> (13.04)	5,960.10 <sub>1</sub> (2,703.83)
12	F	44	67.00	69.74		23.19	24.24		38.57 <sub>1</sub> (33.56)	12,139.98 <sub>1</sub> (7,727.51)

*Note.* P - participant, F - female, M - male, BMI universally given in units of kg/m<sup>2</sup>, weight in kilograms, adherence to the plan expressed as average, and standard deviations noted in brackets. Participants 5, 7, 9 and 12 participated in the study for 2 months. Numbers in subscript indicate lag of significant autocorrelations, and they are further described in autocorrelation sub-section.

### **3.4.2 Compliance with study protocol**

Most participants showed high compliance with wearing the activity monitor (mean 4.58 missing days,  $SD = 5.46$ ), varying from 0% (0 missing days) to 10.49% (19 missing days). The EMA compliance was variable (mean 15.40%,  $SD = 8.42\%$ ), with the number of missing values varying between participants (range 1.71% to 24.60%). Longer data series (beyond 2 months) for three out of eight participants were shortened. Two participants had study breaks due to holiday travel (two weeks for participant 6 and three weeks for participant 1) and one participant's data series was shortened due to low EMA study protocol adherence in the last 4 weeks (the last month was removed from the analysis as compliance with study procedures was below satisfactory for participant 10). Table 6 shows compliance with study procedures, adjusted for time series breaks and effects wearing off.

Table 6: Compliance with EMA procedures

Participant number	Number of total missing values/Number of observation points (days; number of data series)	% of total missing values	Number of days with less than 300 steps
1	436/2534 (181; 14)	17.20%	19
2	612/3204 (178; 18)	24.15%	4
3	220/3276 (182; 18)	6.71%	0
4	53/3094 (182; 17)	1.71%	2
5	142/1054 (62; 17)	13.47%	0
6	669/2890 (170; 17)	23.14%	2
7	144/992 (62; 16)	14.51%	1
8	845/3434 (202; 17)	24.60%	7
9	291/1054 (62; 17)	27.60%	1
10	422/2448 (153; 16)	17.23%	6
11	186/3094 (182; 17)	6.01%	3
12	89/1054 (62; 17)	8.44%	10

*Notes.* Days with less than 300 steps were considered as missing values – usually days when participants forgot to wear activity monitor. Longer data series were adjusted for time series breaks.

### 3.4.3 Time series autocorrelations

Assessment of time series autocorrelations showed that out of 119 data series, 101 showed significant daily autocorrelations (at lag1) and 8 showed significant weekly cycles (at lag7) all of which were controlled for. Table 7 displays which time series showed autocorrelation, numbers in subscript indicate lag of significant autocorrelations which were accounted for (lag1 and lag7).

#### **3.4.4 Descriptive statistics for predictor variables**

The descriptive data for the WLM variables and series with autocorrelation controlled for are also shown in Table 7. The table shows averages and standard deviations of assessed predictive variables. Intra-individual variability in WLM variables was observed in all participants. All variables were measured on 0 - 100 point scale, apart from sleep which is expressed as a number of hours. Seven participants asked to include pain measures, three participants added personal predictors of WLM, namely influence of weather (participant 3) and family (participant 4), and having time to reflect (participant 9). Data from all the predictive variables was cross-correlated with outcome variables (WLM plan adherence and number of steps) for each participant.

Table 7: Predictive variables assessed (averages and standard deviations)

Variable	Motivation			Self-regulation					Habit	Resources				Environment		Other	
	Motivation	Importance	Benefits	Awareness	Obstacles	Confidence	Hunger	Temptation	Routines	Stress	Sleep	Energy level	Happiness	Context	social support	Pain	Additional
1	84.27 <sub>1</sub> (23.21)	89.06 <sub>1</sub> (21.28)	48.76 <sub>1</sub> (28.45)	87.44 <sub>1</sub> (22.23)	60.10 (29.11)	80.47 <sub>1</sub> (25.45)	87.81 <sub>1</sub> (26.58)	65.05 (28.46)	73.41 <sub>1</sub> (29.68)	56.15 <sub>1</sub> (27.88)	7.06 (0.98)	58.23 <sub>1</sub> (15.93)	86.94 <sub>1</sub> (20.22)	77.55 <sub>1</sub> (29.02)	77.88 <sub>1</sub> (28.79)		67.49 <sub>1</sub> (26.28)
2	87.62 <sub>1</sub> (23.70)	94.02 <sub>1</sub> (16.57)	81.06 <sub>1</sub> (27.96)	88.93 <sub>1</sub> (21.92)	72.88 <sub>1</sub> (33.56)	87.31 <sub>1</sub> (22.67)	65.56 (27.62)	65.33 (35.02)	43.33 <sub>7</sub> (27.42)	70.84 <sub>1</sub> (29.95)	5.08 <sub>1</sub> (1.19)	66.75 <sub>1</sub> (30.28)	75.11 <sub>1</sub> (26.41)	79.24 <sub>1</sub> (31.41)	57.99 <sub>1</sub> (32.32)	47.91 (26.27)	
3	87.33 <sub>1</sub> (12.67)	96.10 <sub>1</sub> (9.03)	85.33 <sub>1</sub> (14.67)	92.20 (11.59)	63.06 <sub>1</sub> (31.19)	81.83 <sub>1</sub> (13.49)	64.17 <sub>1</sub> (20.81)	38.02 <sub>1</sub> (28.64)	61.40 <sub>1</sub> (31.54)	52.52 <sub>1</sub> (28.29)	6.76 <sub>7</sub> (0.90)	73.09 <sub>1</sub> (16.91)	52.55 <sub>1</sub> (26.29)	65.54 <sub>1</sub> (32.30)	49.56 <sub>1</sub> (22.66)	14.88 <sub>1</sub> (15.97)	4.59 (13.01)
4	69.64 (13.30)	68.06 <sub>1</sub> (13.75)	58.23 <sub>1</sub> (16.45)	68.94 <sub>1</sub> (13.08)	51.31 (21.79)	62.37 (15.42)	56.49 <sub>1</sub> (15.17)	60.22 <sub>1</sub> (20.01)	68.92 <sub>1</sub> (14.17)	55.14 (17.93)	8.01 (1.00)	53.79 (16.59)	53.63 (15.13)	59.80 <sub>1</sub> (20.92)	42.06 (20.92)		55.13 <sub>7</sub> (23.47)
5	65.30 <sub>1</sub> (16.92)	65.40 <sub>1</sub> (16.86)	47.30 (19.68)	64.80 <sub>1</sub> (18.13)	43.90 (24.58)	59.50 (15.76)	47.40 (18.96)	42.30 (17.40)	56.90 (20.73)	60.20 <sub>1</sub> (25.18)	6.90 (0.58)	49.90 (17.95)	55.20 (16.76)	53.80 <sub>7</sub> (21.93)	34.50 (17.35)	25.70 (21.00)	
6	97.40 <sub>1</sub> (8.00)	99.32 <sub>1</sub> (3.68)	98.42 <sub>1</sub> (9.70)	99.98 <sub>1</sub> (0.02)	84.45 <sub>1</sub> (22.97)	93.79 <sub>1</sub> (14.40)	80.91 (12.26)	89.62 <sub>1</sub> (15.45)	90.54 (17.13)	84.20 (13.47)	6.77 (0.97)	72.63 <sub>7</sub> (13.80)	89.87 <sub>1</sub> (10.80)	85.91 <sub>1</sub> (23.08)	99.92 <sub>1</sub> (0.89)	21.35 <sub>1</sub> (28.64)	
7	78.10 (13.07)	80.80 (10.11)	82.20 (10.91)	83.10 (9.87)	56.90 (24.25)	73.10 <sub>7</sub> (14.20)	70.30 <sub>7</sub> (15.46)	57.20 (22.30)	66.00 (22.53)	68.30 (14.96)	7.00 (0.71)	61.80 (16.17)	75.40 (13.79)	62.80 (28.59)	64.60 (19.31)		
8	97.33 (10.18)	97.78 (10.17)	98.21 (10.07)	99.05 (5.38)	90.74 <sub>1</sub> (19.19)	96.38 (12.06)	86.89 (15.95)	86.38 (17.93)	93.69 (14.08)	93.10 <sub>1</sub> (18.10)	6.86 (1.25)	86.11 <sub>1</sub> (21.38)	95.23 (14.72)	93.03 <sub>1</sub> (23.15)	97.29 (10.46)	30.72 <sub>1</sub> (29.45)	
9	71.00 (17.49)	74.90 <sub>1</sub> (16.92)	37.00 (18.05)	59.50 (20.38)	48.00 (21.56)	64.50 (17.10)	52.10 (18.87)	44.70 (21.80)	49.80 (16.85)	58.30 (23.11)	6.80 (1.34)	55.80 (23.62)	57.90 (19.02)	61.40 (24.56)	51.90 (15.90)		52.70 (17.29)
10	58.37 <sub>1</sub> (21.75)	50.49 <sub>1</sub> (23.10)	44.61 <sub>1</sub> (22.55)	47.83 <sub>1</sub> (24.50)	37.88 <sub>1</sub> (22.96)	58.63 <sub>1</sub> (21.99)	59.55 <sub>1</sub> (20.30)	33.93 <sub>1</sub> (21.44)	45.70 <sub>1</sub> (25.62)	55.37 <sub>1</sub> (25.95)	8.13 (1.21)	48.12 <sub>1</sub> (20.36)	66.36 <sub>1</sub> (16.47)	48.72 <sub>1</sub> (23.62)	45.14 <sub>1</sub> (22.45)		
11	67.81 <sub>1</sub> (12.90)	72.12 <sub>1</sub> (12.84)	60.98 <sub>1</sub> (15.35)	56.17 <sub>1</sub> (14.57)	47.63 <sub>1</sub> (15.32)	62.22 <sub>1</sub> (11.92)	51.32 <sub>1</sub> (13.27)	49.90 <sub>1</sub> (14.34)	55.95 <sub>1</sub> (15.54)	57.41 <sub>1</sub> (19.04)	6.73 (0.99)	54.29 <sub>1</sub> (18.13)	63.75 <sub>1</sub> (16.89)	57.31 <sub>7</sub> (15.80)	33.47 <sub>1</sub> (13.87)	24.14 <sub>1</sub> (24.56)	
12	61.10 <sub>1</sub> (28.23)	59.10 <sub>1</sub> (28.49)	98.00 (12.24)	67.10 <sub>1</sub> (29.05)	87.10 (23.55)	45.80 (32.86)	87.90 (24.61)	31.10 (33.28)	41.60 <sub>1</sub> (35.34)	85.70 (29.82)	7.00 (1.87)	68.90 <sub>1</sub> (20.05)	90.00 (14.89)	67.20 (39.71)	7.80 (17.89)	5.00 (11.83)	

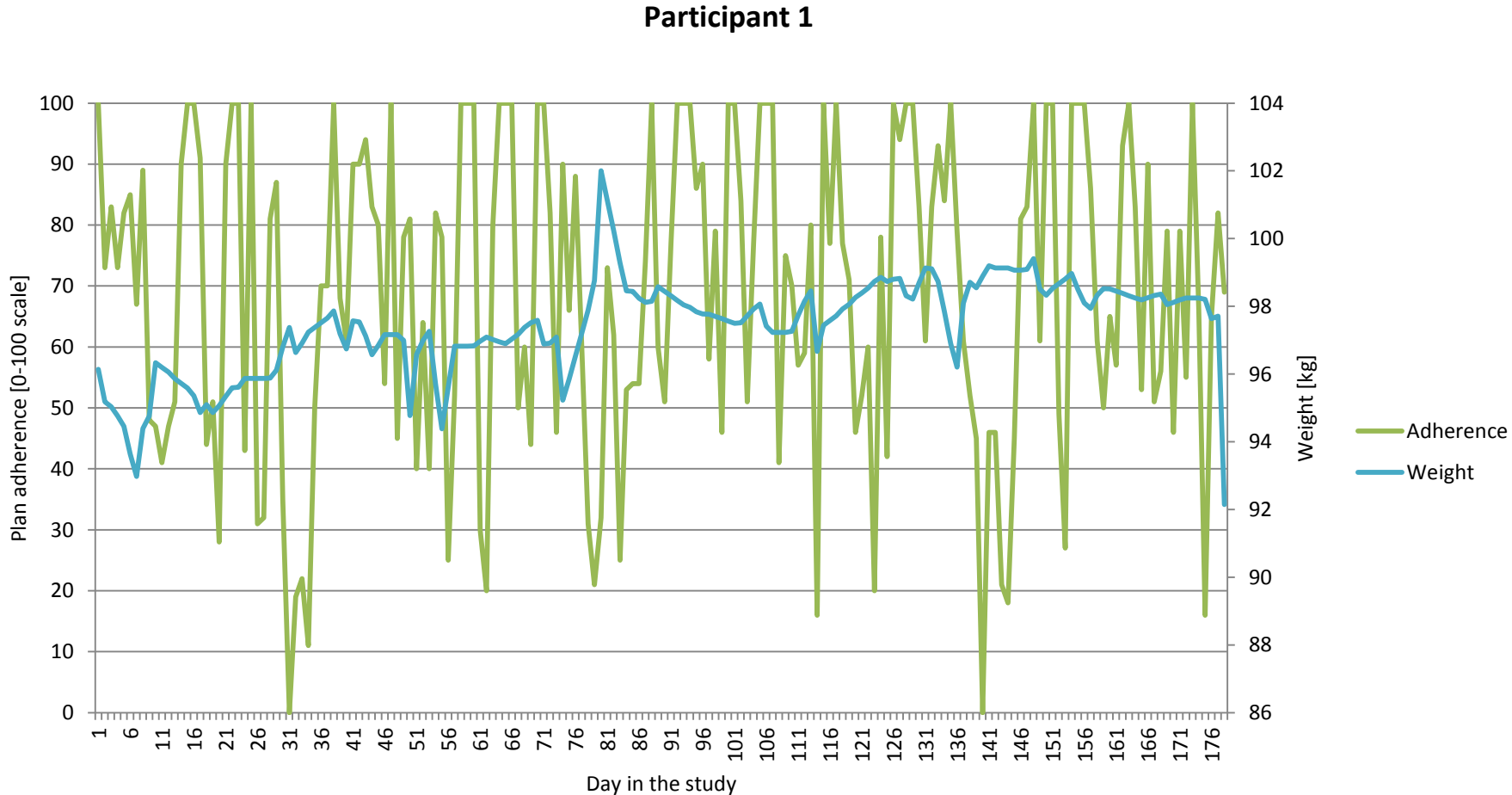
Notes. Numbers in subscript indicate lag of significant autocorrelations, *n* vary for each participant. Standard deviations given in brackets.



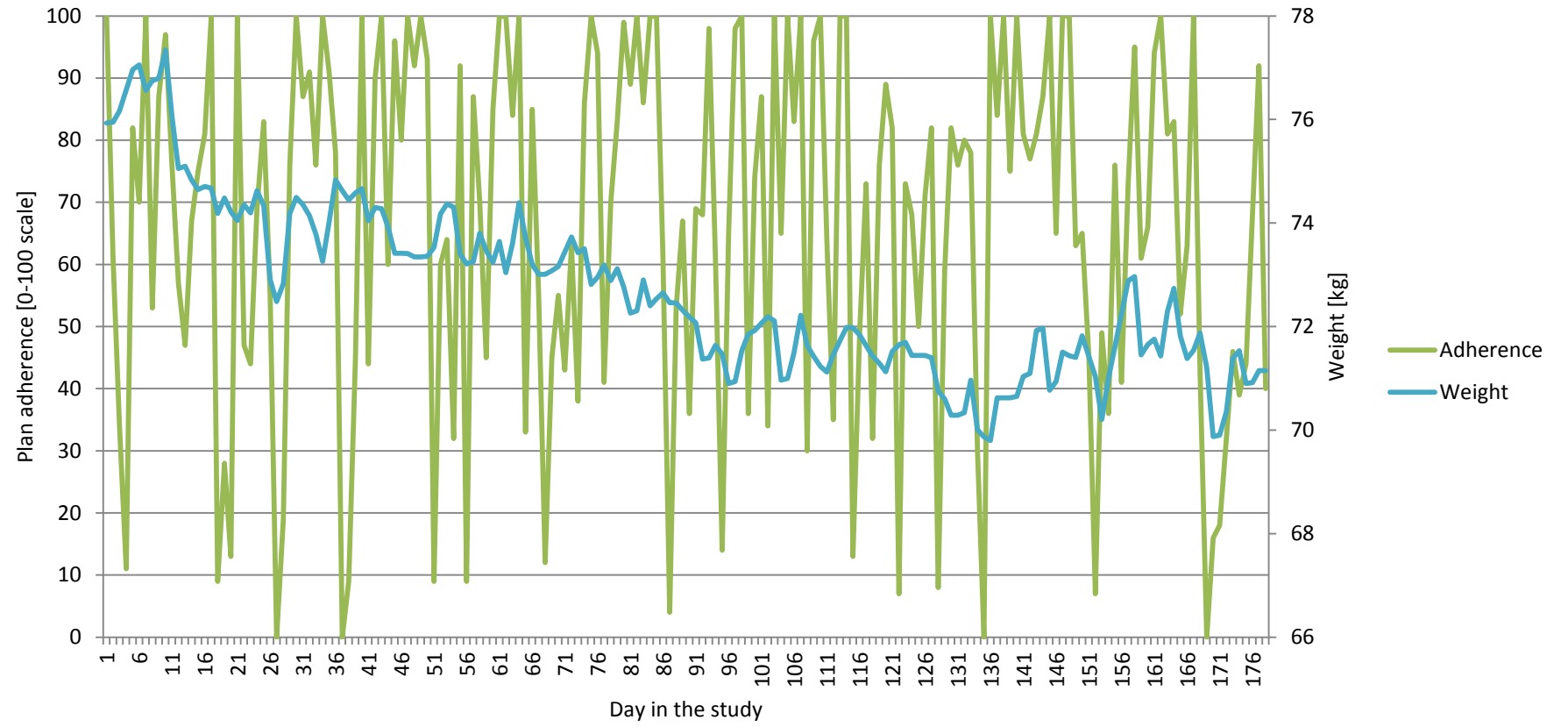
### **3.4.5 Predicting objective measures of weight**

The weight and plan adherence for each participant across the study period is displayed in Figure 5. Graphs show how self-reported plan adherence corresponds with weight changes, slow and gradual weight changes were usually associated with changes in plan adherence. For instance periods of low adherence to the plan are followed by weight gains, which can be observed on the weight and WLM plan adherence time plots. Out of 12 individuals, three had slow and gradual weight increase (participants 1, 11 and 12), three had gradual weight decrease (participants 2, 3 and 8), three had stable weight with small fluctuations (participants 4, 5 and 9) and two showed weight decrease at the beginning of the study and then gradual increase in the following months (participants 6 and 10). For participants who gained weight during the study, an overall weight loss of at least 5% was still maintained.

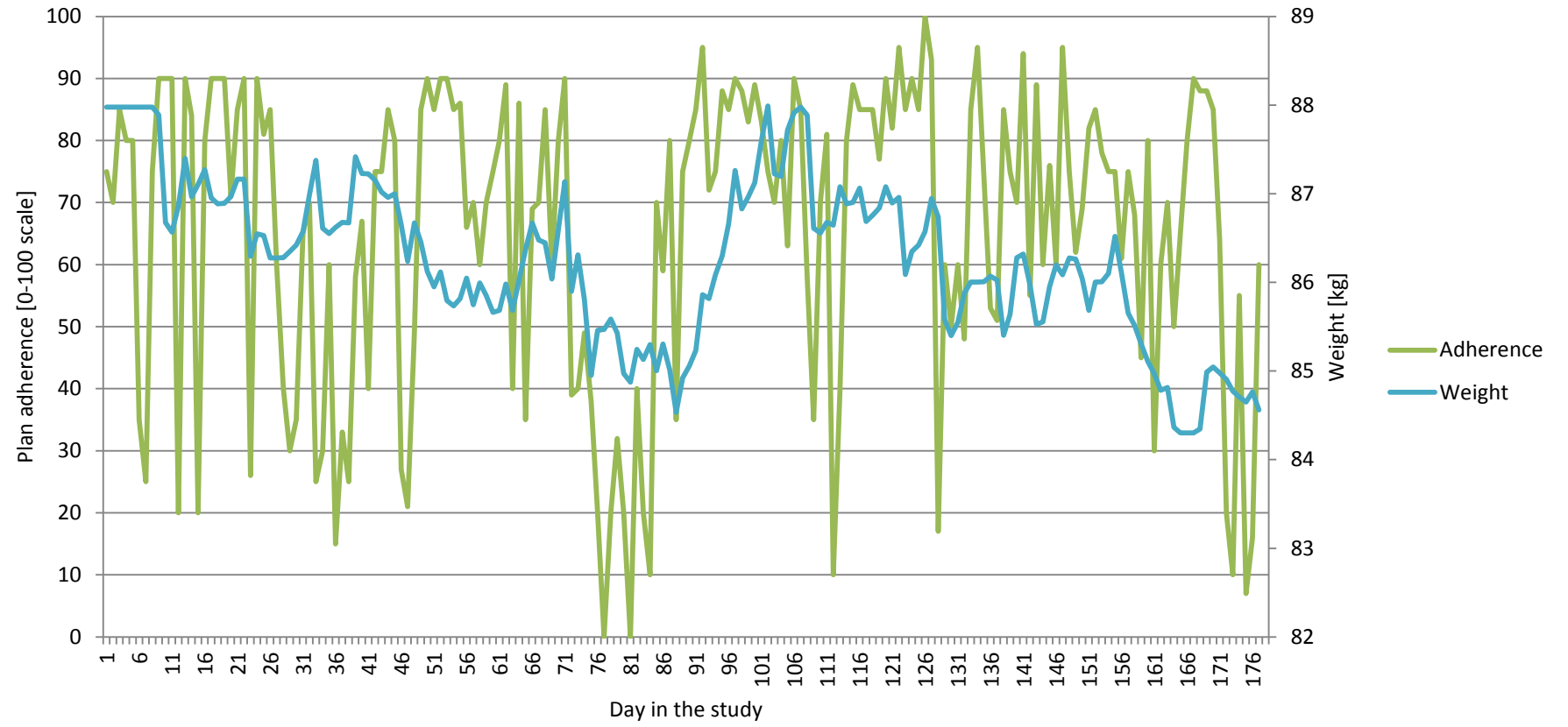
Figure 5: Weight and WLM plan adherence time plots for 12 study participants



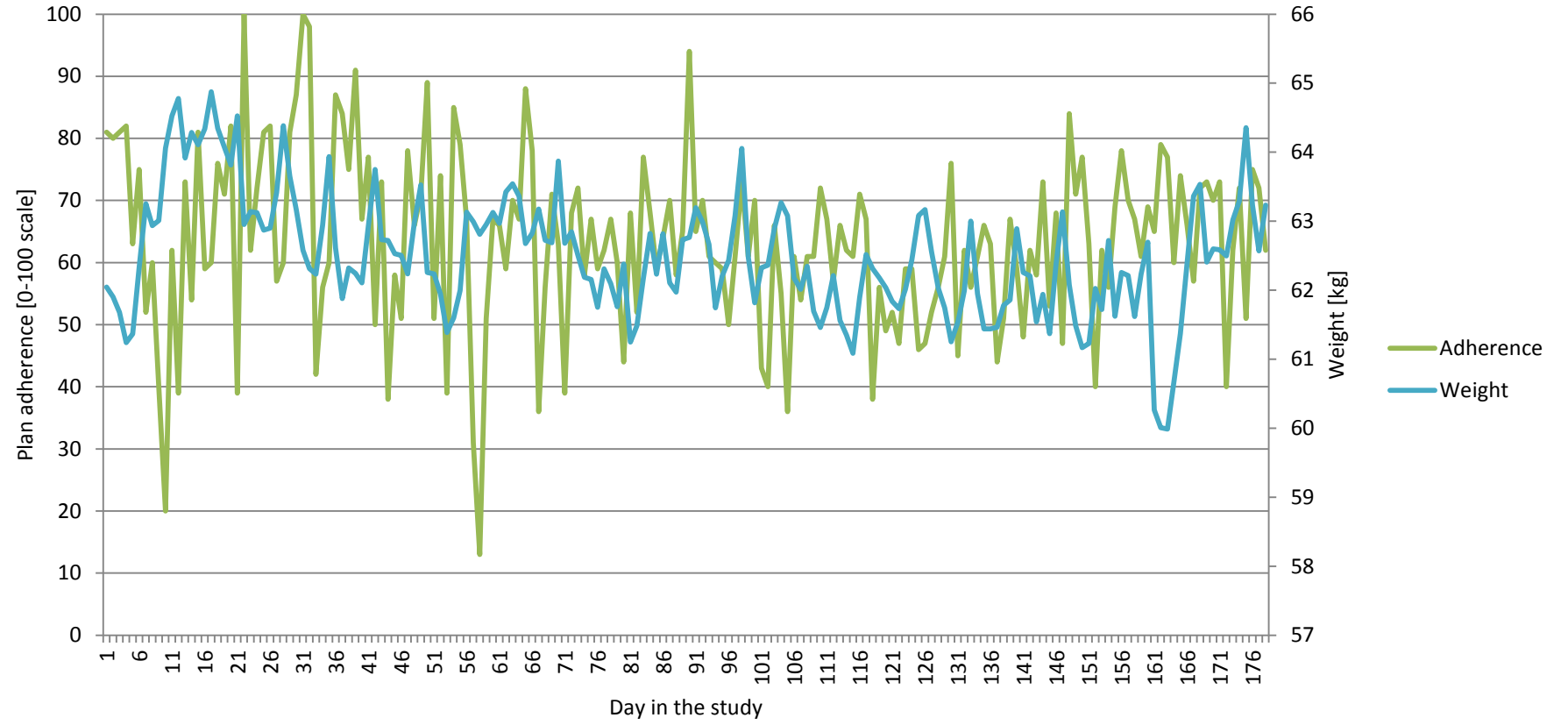
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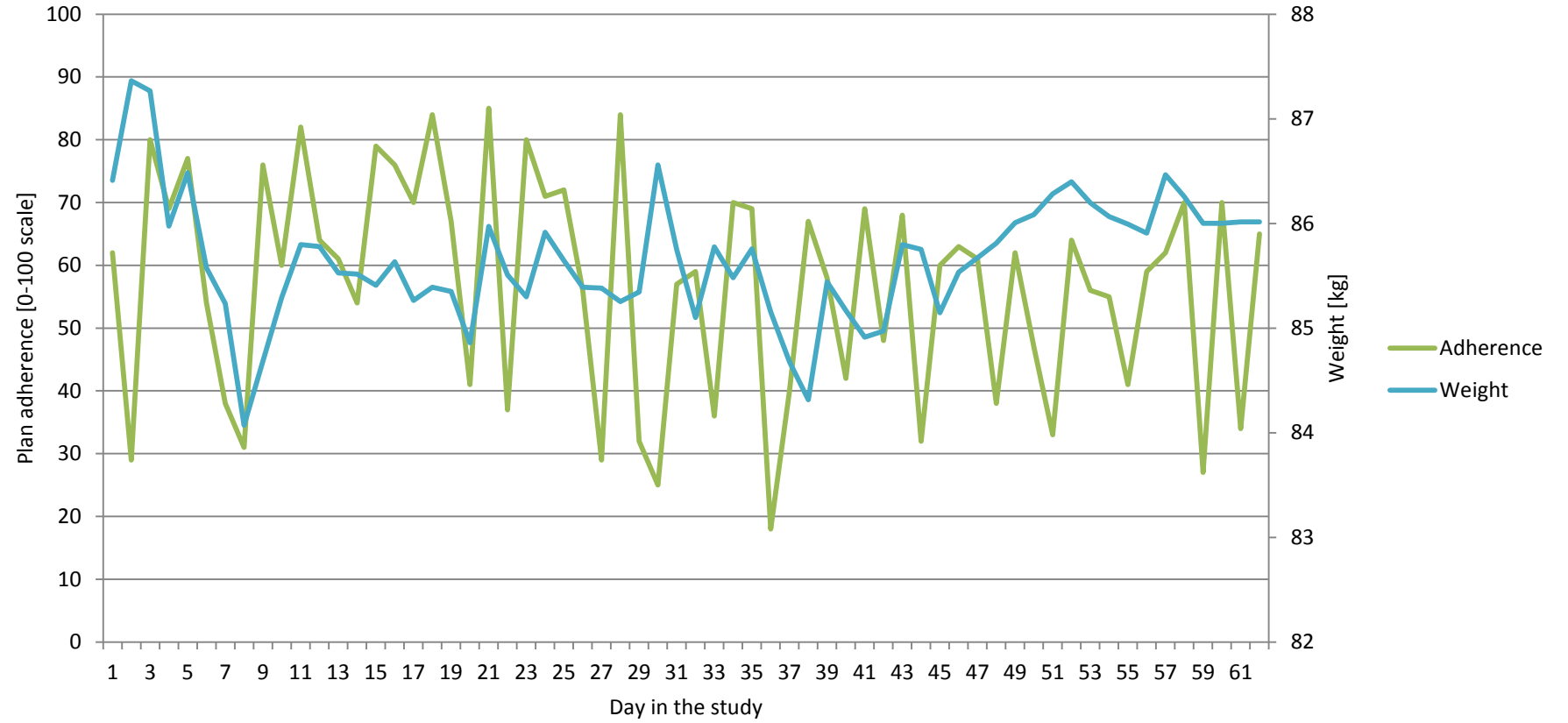
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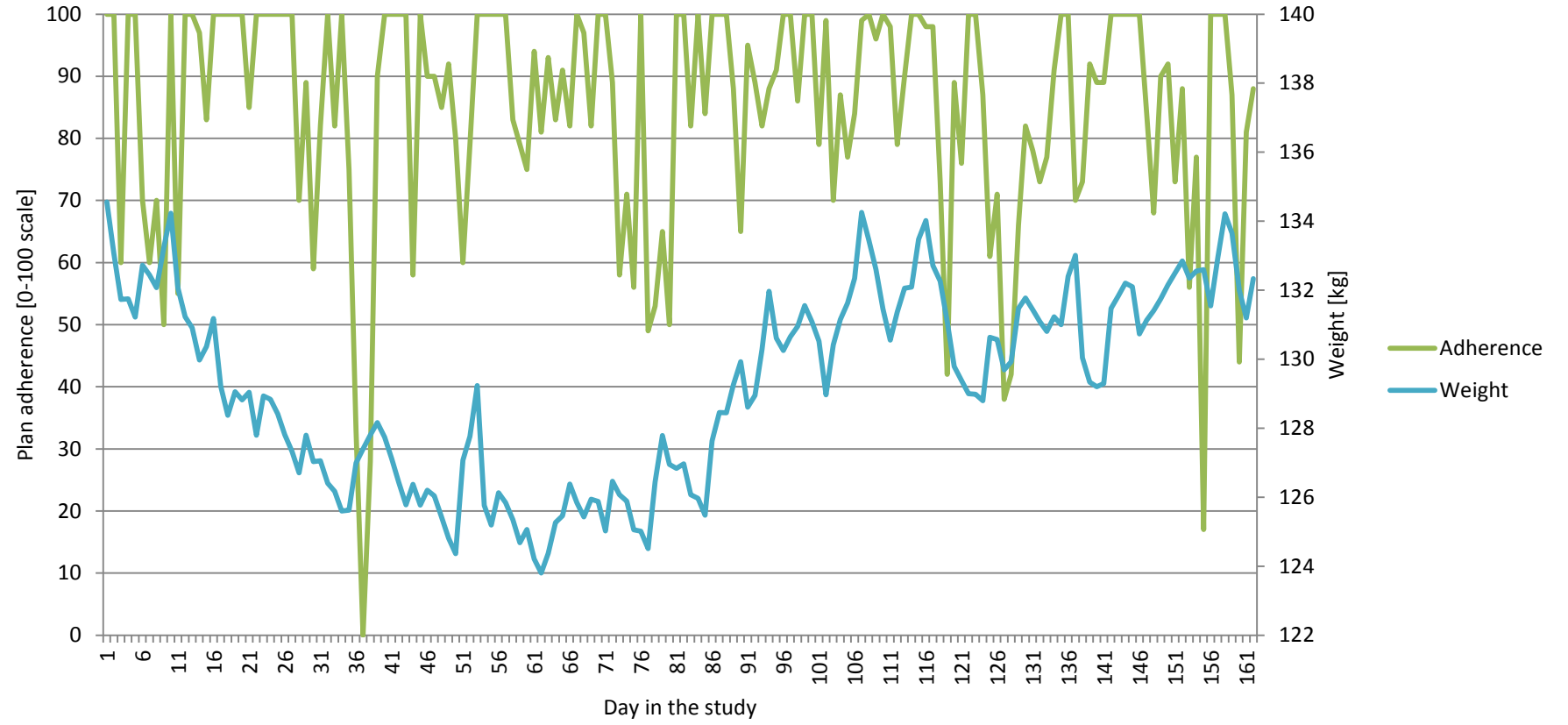
### Participant 4



### Participant 5



### Participant 6

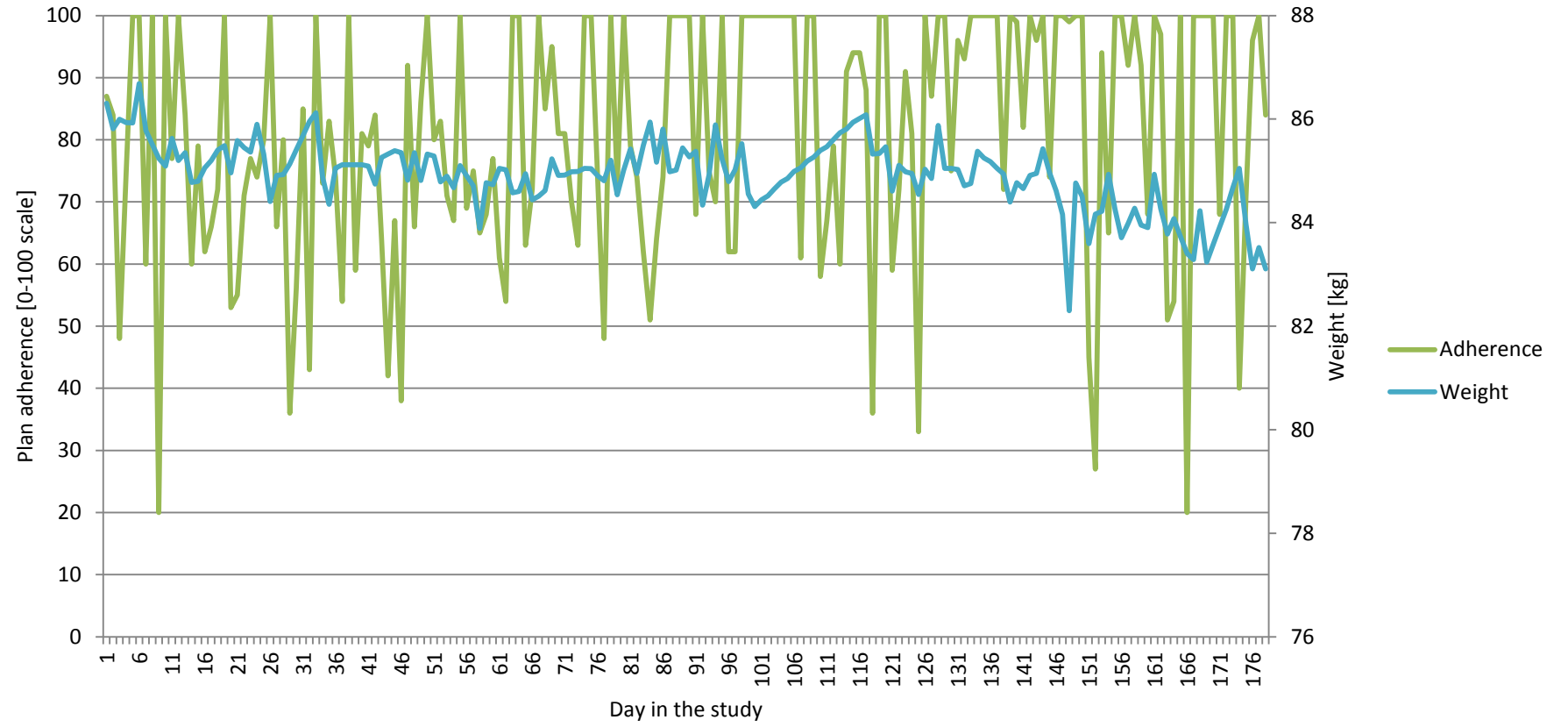


### Participant 7

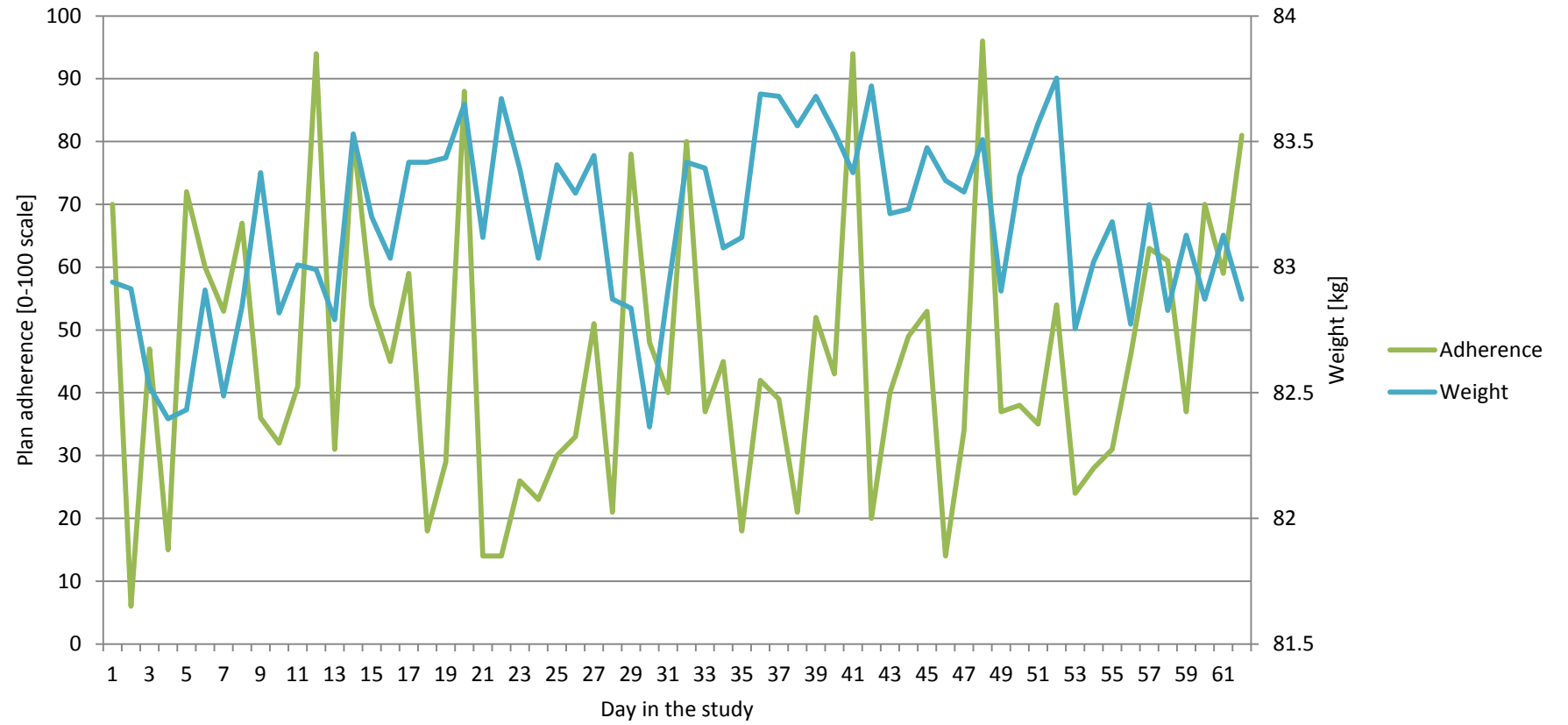




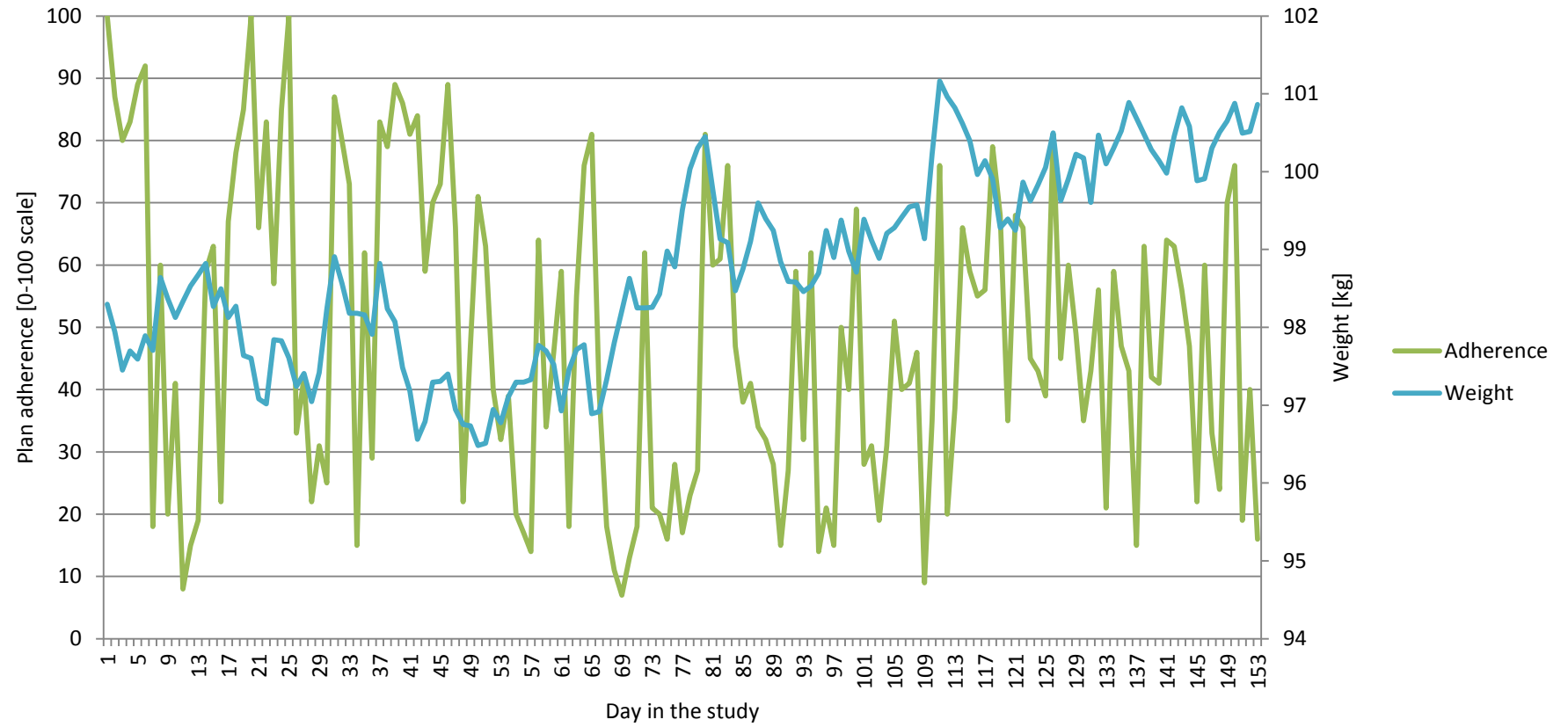
### Participant 8



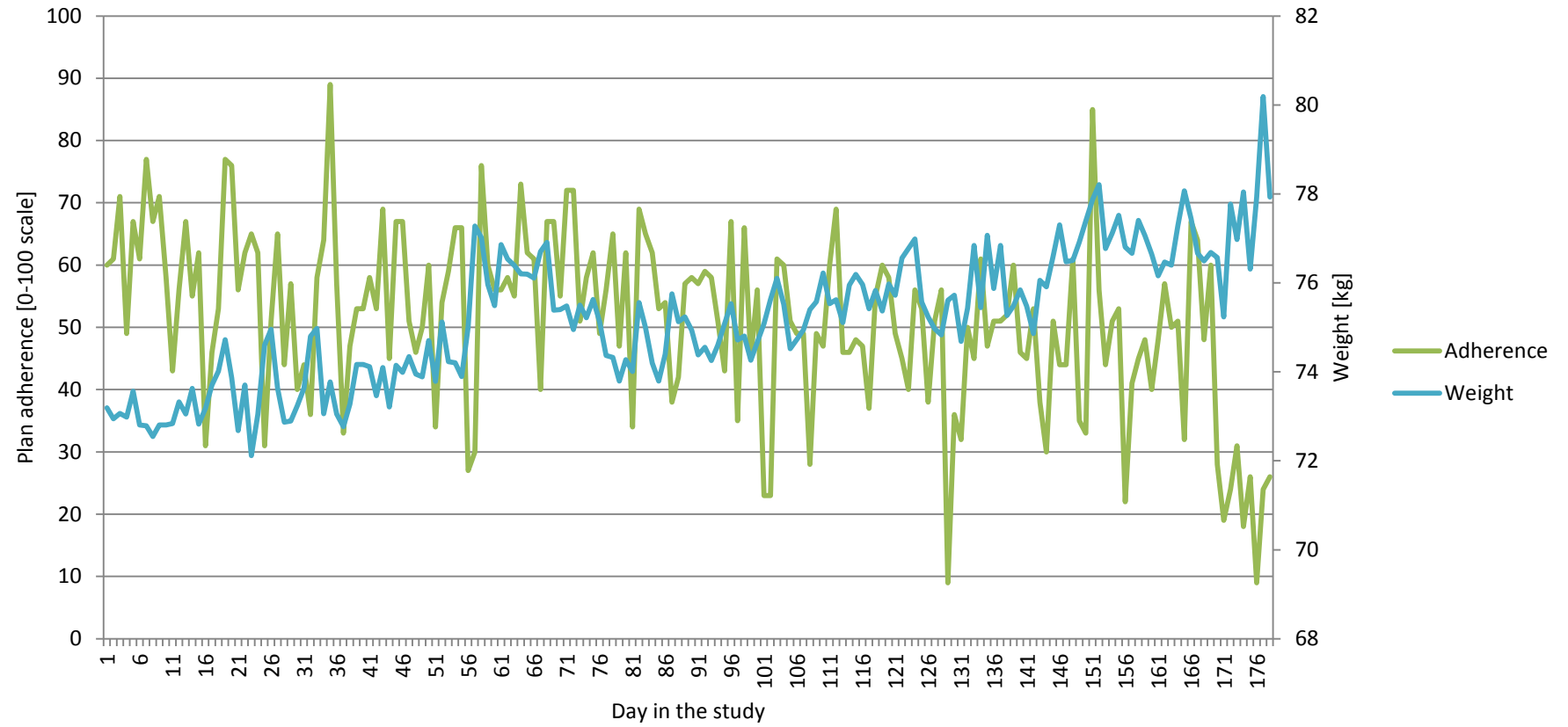
### Participant 9



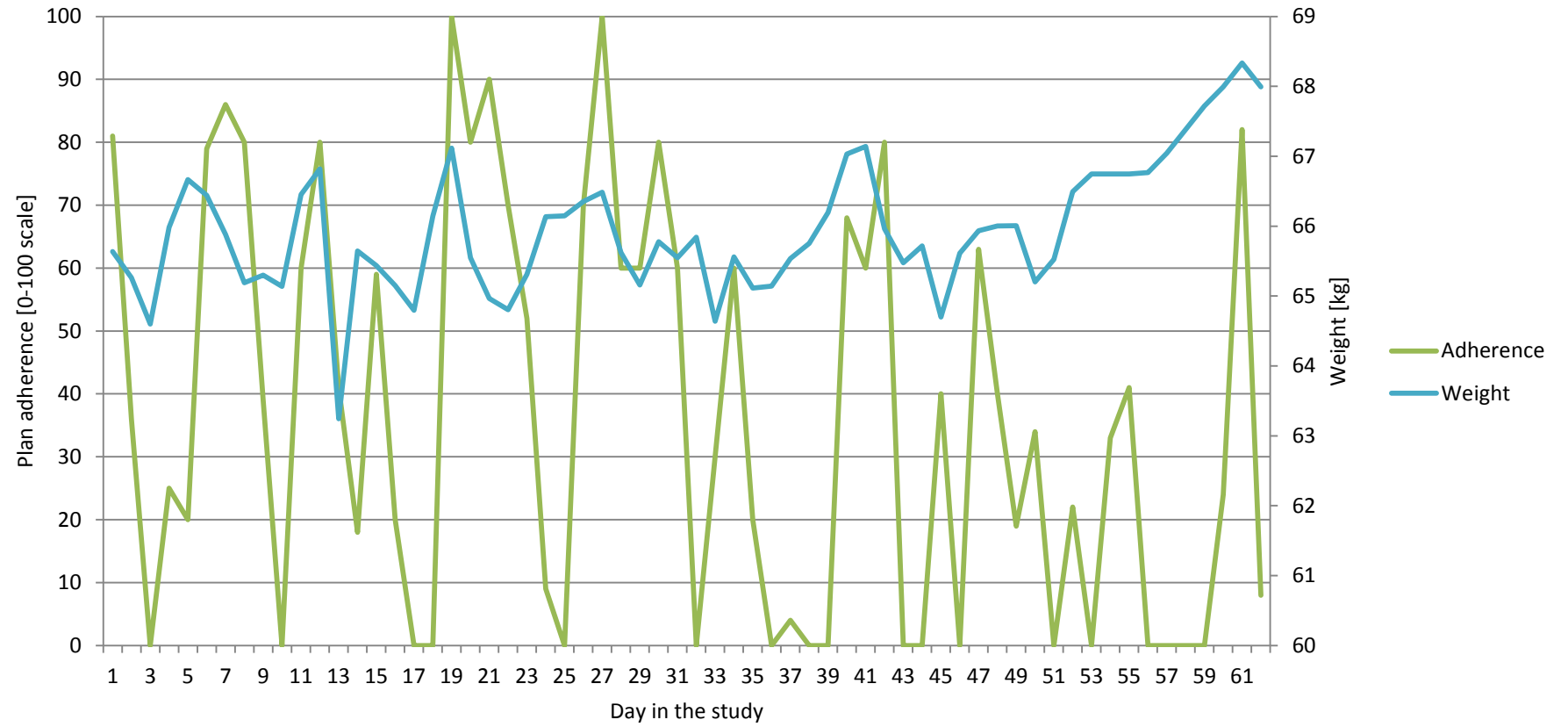
### Participant 10



### Participant 11



### Participant 12



### **3.4.6 Predicting self-reported WLM plan adherence**

For each participant bivariate relationships between each theory-driven predictor and self-reported WLM plan adherence were examined (Table 8). The number of assessed relationships ranged from 15 to 17 per participant. In total, 191 separate relationships between predictor and self-reported WLM plan adherence were examined, 140 of which reached significance (i.e. cross correlations that exceeded 95% CIs) and all apart from four showed variability (four showing a ceiling effect with participants rating the maximum value 100). Table 8 includes cross correlations and time lags between all predictors and self-reported WLM plan adherence.

#### **3.4.6.1 Maintenance motives**

Motivation was usually associated with WLM plan adherence which was significant in all apart from one participant (range  $r_{lag0}=.19-.58$ ). The higher the reported motivation to follow WLM plan, the better the WLM plan adherence reported for that day. The correlation coefficients ranged from small to very large, and the majority showed medium strength correlations<sup>4</sup>. Importance (range  $r_{lag0}=.26-.53$ ) and appreciation of weight loss benefits (range  $r_{lag0}=.28-.54$ ) were less predictive and showed significant correlations in all apart from three participants. The higher the importance of WLM, and the more person appreciated the benefits of WLM,

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<sup>4</sup> The description follows the standard classification: correlation coefficients between 0 and 0.1 are considered very small, correlation coefficients between .10 and .30 are considered small, from .30 to .50 medium, from .50 to .70 high, between .70 to .90 very high, and above .90 nearly complete (Hopkins, 1997; Kotrlik & Williams, 2003).

the higher the WLM plan adherence. The correlations coefficients were mainly small and medium for these two variables respectively.

#### **3.4.6.2 Self-regulation**

Awareness of the WLM plan (range  $r_{lag0}=.31-.69$ ) significantly predicted the WLM plan adherence in all twelve participants; correlation coefficients were medium in five participants and high in seven participants. On the days when participants were more aware of their WLM plan, their WLM plan adherence was consistently rated higher.

Confidence and temptations were usually associated with WLM plan adherence, which was significant in all apart from one participant for both confidence (range  $r_{lag0}=.26-.57$ ), and temptations (range  $r_{lag0}=0.19-0.74$ ). The higher the confidence to follow WLM plan reported, the better the WLM plan adherence reported for that day. On the days when participants faced more temptations to break their WLM plan, they were less likely to follow the WLM plan. The majority of correlation coefficients for confidence and plan adherence were medium. For temptation and plan adherence, cross-correlations were small in two participants, medium in one, high in five and very high in three participants.

The number of obstacles to follow WLM plan showed significant associations with WLM plan adherence in all apart from two participants ( $r_{lag0}=.29-.70$ ); the higher the number of reported obstacles, the lower WLM plan adherence. The correlation coefficients were small in two participants, medium in one and high in seven

participants. Hunger had lower predictive utility ( $r_{lag0}=.31-.61$ ) and significantly correlated with plan adherence in only six participants, showing medium correlation coefficients in five participants and high in one participant; the higher the hunger levels, lower the WLM plan adherence.

#### **3.4.6.3 Resources**

Energy levels showed significant associations with WLM plan adherence in all apart from two participants ( $r_{lag0}=.26-.60$ ). High energy levels were associated with high WLM plan adherence, with small correlations in two participants, medium in seven and large in two. Happiness ( $r_{lag0}=.15-.45$ ) was associated with plan adherence in eight out of twelve participants, with small and medium correlations. Pain showed the lowest predictive utility and was non-significant in 6 out of 7 participants who chose to include this variable. Stress and sleep were non-significant in seven and ten participants respectively, with mainly small correlation coefficients.

#### **3.4.6.4 Habit**

Routines were the most consistent predictor of WLM plan adherence (range  $r_{lag0}=.15-.80$ ), significantly predicting WLM plan adherence in all 12 participants. On the days when participants were more likely to follow their routines, their WLM plan adherence was consistently rated higher. The correlation coefficients were found to be high in four and very high in five participants, however only medium in two and small in one participant.



Table 8: Cross correlations between adherence to the WLM plan and theoretical WLM variables

Theme	Motivation			Self-regulation					Habit	Resources				Environment		Other	
Variable	Motivation	Importance	Benefits	Awareness	Obstacles	Confidence	Hunger	Temptation	Routines	Stress	Sleep	Energy level	Happiness	Context	Social support	Pain	Additional
P1 (0.075)	.320**	.293**	.422**	.575**	.295**	.335**	.026	.194**	.775**	-.049	-.122	-.006	.140	.530**	.645**	na	na
P2 (0.076)	.369**	.259**	.446**	.475**	.579**	.448**	.317**	.382**	.156*	.270**	.066	.433**	.450**	.327**	.183*	-.042	na
P3 (0.076)	.375**	.267**	.284**	.329**	.709**	.342**	- .327**	.559**	.720**	-.016	-.123	.342**	-.031	.605**	.452**	-.149	- .225**
P 4 (0.076)	.303**	.279**	.484**	.482**	-.033	.268**	.027	.049	.487**	-.066	.197*	.421**	.391**	.324**	.293**	na	- .216**
P5 (0.135)	.073	.021	.251	.394**	.266*	.240	-.020	.525**	.461**	.114	.220	.261*	.145	.408**	.030	.054	na
P 6 (0.080)	.194*	.094	.308**	.339**	.622**	.342**	.398**	.743**	.680**	.196*	-.031	.329**	.162*	.591**	.423**	.090	na
P 7 (0.135)	.582**	.362**	.110	.351**	.632**	.578**	.374**	.685**	.728**	.336*	.189	.607**	.330*	.420**	.548**	na	na
P8 (0.071)	.307**	.355**	.545**	.601**	.571**	.354**	.611**	.726**	.724**	.455**	-.060	.502**	.392**	.414**	.519**	-.020	na

Theme	Motivation			Self-regulation					Habit	Resources				Environment		Other	
Variable	Motivation	Importance	Benefits	Awareness	Obstacles	Confidence	Hunger	Temptation	Routines	Stress	Sleep	Energy level	Happiness	Context	Social support	Pain	Additional
P9 (0.128)	.362**	.145	.285*	.312*	.340*	.395**	.085	.278*	.501**	.305*	-.126	.474**	.297*	.139	.199	na	0.053
P 10 (0.081)	.321**	.336**	.500**	.695**	.585**	.430**	.066	.545**	.801**	.055	.074	.457**	.289**	.669**	.632**	na	na
P11 (0.075)	.469**	.456**	.467**	.587**	.545**	.426**	.319**	.570**	.604**	.134	-.035	.390**	.153*	.546**	.191*	- .172*	na
P12 (0.128)	.470**	.531**	-.117	.521**	.116	.472**	-.035	.747**	.536**	-.011	.287*	.076	.175	.194	-.021	-.045	na

Notes. NA – not applicable; standard error for lag0 in brackets. \*\*Correlation is significant at the 0.01 level, \* at the 0.05 level (2-tailed); non-significant correlation – did not reach 95% CI.

#### **3.4.6.5 Environment**

Environmental influences showed significant associations with WLM plan adherence in all apart from two participants ( $r_{lag0}=.32-.67$ ). Typicality of the environment was associated with high WLM plan adherence, with medium and large correlation coefficients. Social support ( $r_{lag0}=.18-.64$ ) was significantly associated with plan adherence in all apart from three participants, with small correlation coefficients in three participants, medium in two and high in four participants.

#### **3.4.6.6 Self-selected variables**

In three participants who self-selected additional variables that they believed were predictive for their WLM plan adherence, two selected variables that showed significant correlation with outcome, namely weather ( $r_{lag0}=-.22$ ) and impact of the family on participant's WLM plan adherence ( $r_{lag0}=-0.22$ ). These participants were less likely to follow their WLM plans when the weather was bad (participant 3) or when the family had an impact on participant's WLM (participant 4). One participant selected a predictor which showed non-significant correlation with the outcome, namely having time to reflect on WLM (participant 9).

#### **3.4.7 Predicting physical activity**

The relationship between each predictor and levels of physical activity (measured as number of steps per day) was assessed (Table 9). In total 202 correlations were examined, with 91 shown to be significant. Table 9 shows cross-correlations for

each of the predictors and step count measures; it also includes cross-correlations between two outcomes (WLM plan adherence and step count). The strongest correlations for number of steps recorded daily were with self-reported energy levels, significant in ten out of twelve participants ( $r_{lag0}=.32-.63$ ), and with confidence to follow WLM plan, significant in nine out of twelve participants ( $r_{lag0}=.14-.34$ ). The higher the energy level on the given day, the higher the physical activity level, with medium correlation coefficients in seven participants and high in three. The higher the confidence to adhere to the WLM plan, the higher number of steps that day, although with largely medium or small correlation coefficients.

Other important predictors of activity were number of obstacles ( $r_{lag0}=.15-.35$ ) and ability to rely on routines ( $r_{lag0}=.16-.44$ ), both significant in eight out of twelve participants, showing small and medium correlations. The higher the number of obstacles to follow the WLM plan, the lower the step count and the higher the ability to rely on routines, the higher the step-count. In eight out of twelve participants WLM plan adherence was significantly cross-correlated with the step count on that day ( $r_{lag0}=.18-.45$ ) with only small and medium correlations.

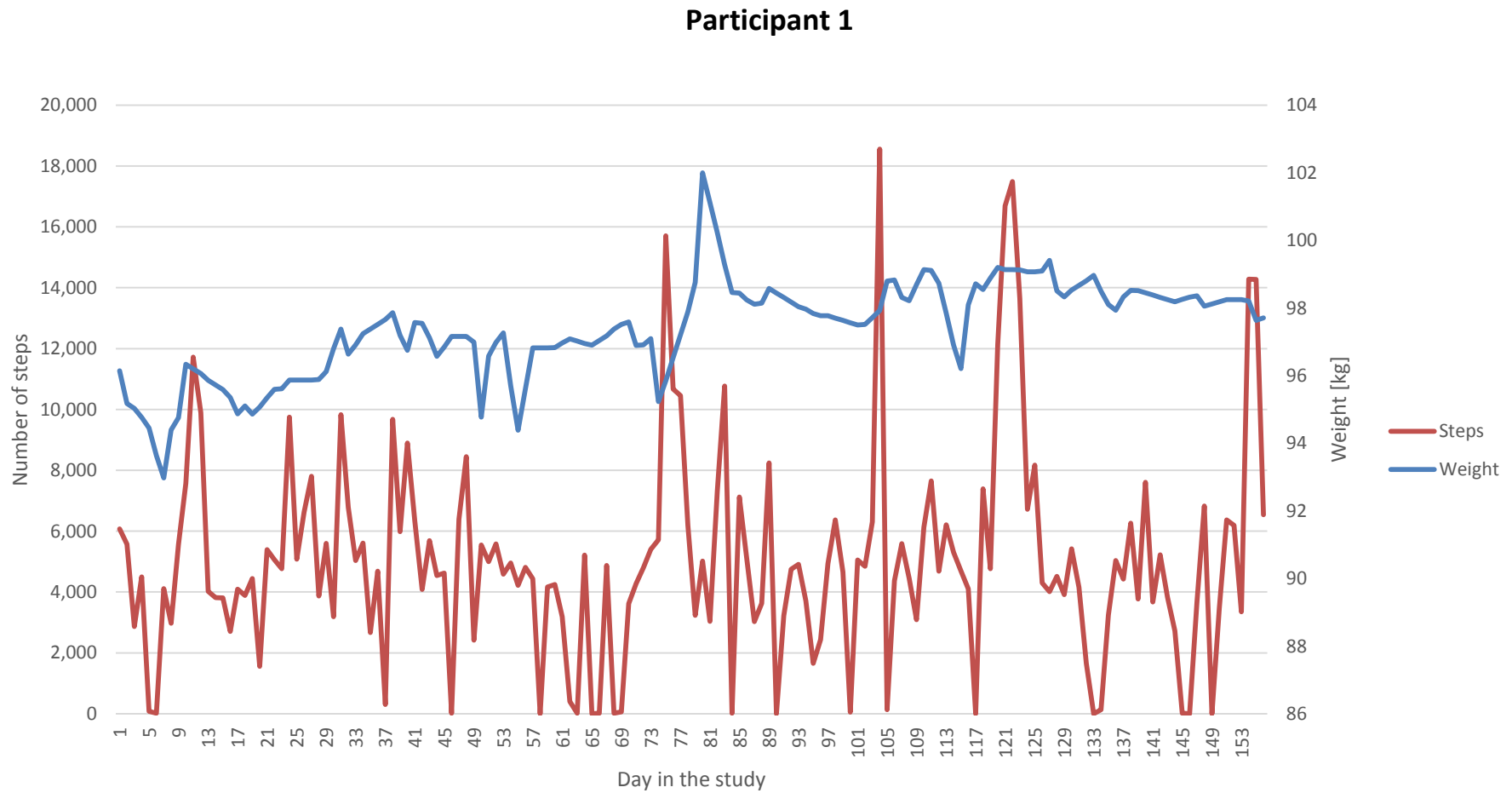
Variables that were least likely to be associated with the step count were social support, pain and hunger. Cross-correlation for social support was non-significant in ten participants and for pain and hunger in nine out of twelve participants respectively. One additional self-selected personal variable showed significant cross-correlation with step count, namely the influence of weather on the WLM plan adherence, but only a small correlation coefficient (participant 3:  $r_{lag0}=-.21$ )

was observed. There was a high variation in the number of explanatory variables which correlated with step-count (CI 95%) ranging from only two variables in one participant (participant 10) up to fourteen variables in another (participant 8). Different variables were predictive for different participants in terms of strength of the correlation with step count. Step count data showed less clear pattern of results and lower cross correlations than WLM plan adherence (Figure 6).

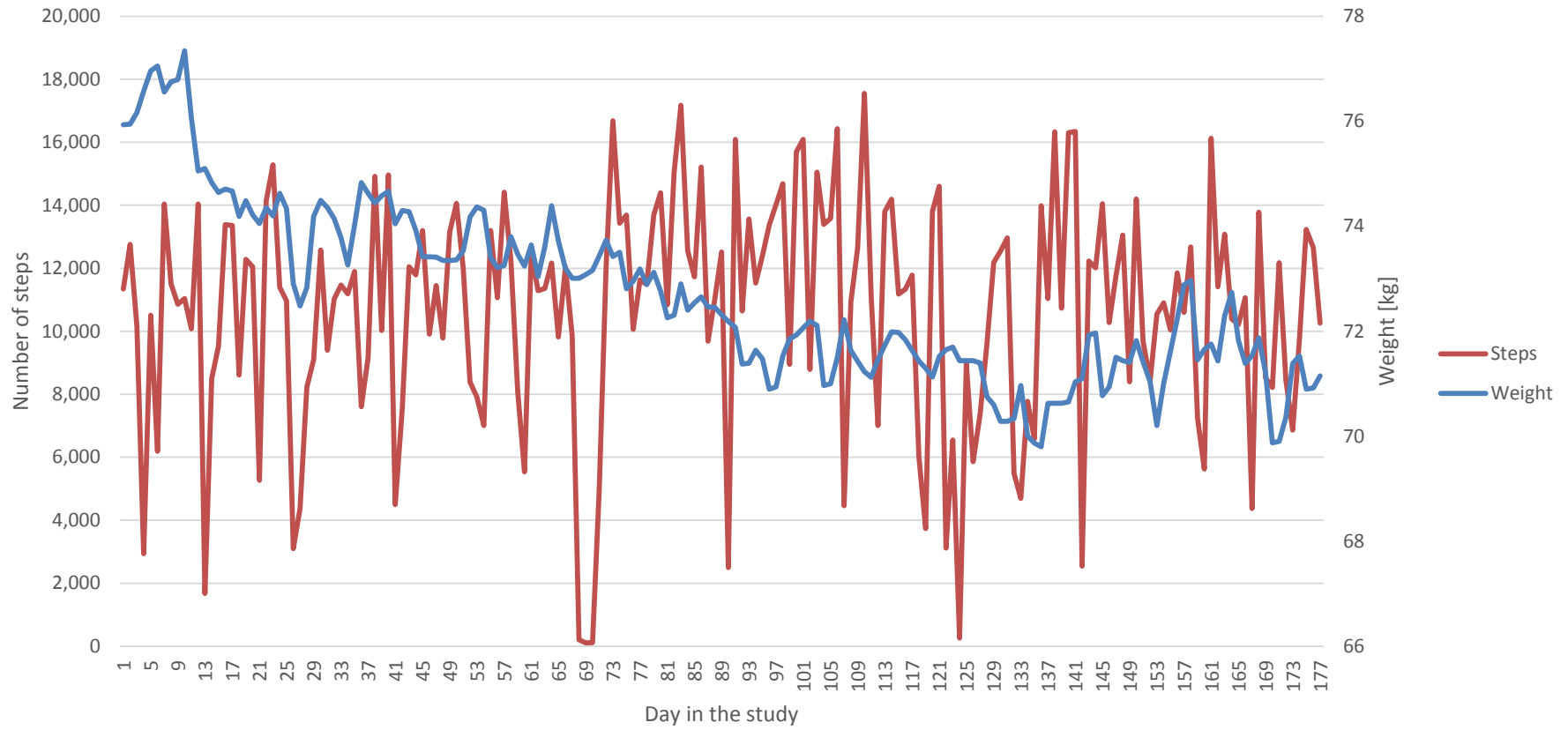
#### **3.4.8 Other time lags and longer versus shorter time series**

The sensitivity analysis has shown that lag0 was commonly the highest compared to cross-correlations at other time lags (lag1 and lag-1). In rare cases when cross-correlation at time lags different from 0 were higher, often both time lags (e.g. lag0 and lag1) for the same comparison were non-significant. For both shorter and longer time series most of the variables were correlated at time lag0 indicating cross-correlation on the same day; however some showed a relationship at different time points, e.g. lag-1 suggesting that the explanatory variable precedes the outcome. There were no significant differences in the outcome variables in the before and after feedback session. In the same participants a higher number of significant correlations was observed at the longer time assessment (up to 6 months) than at 2 months; however, in longer data series the power to detect significant differences was higher.

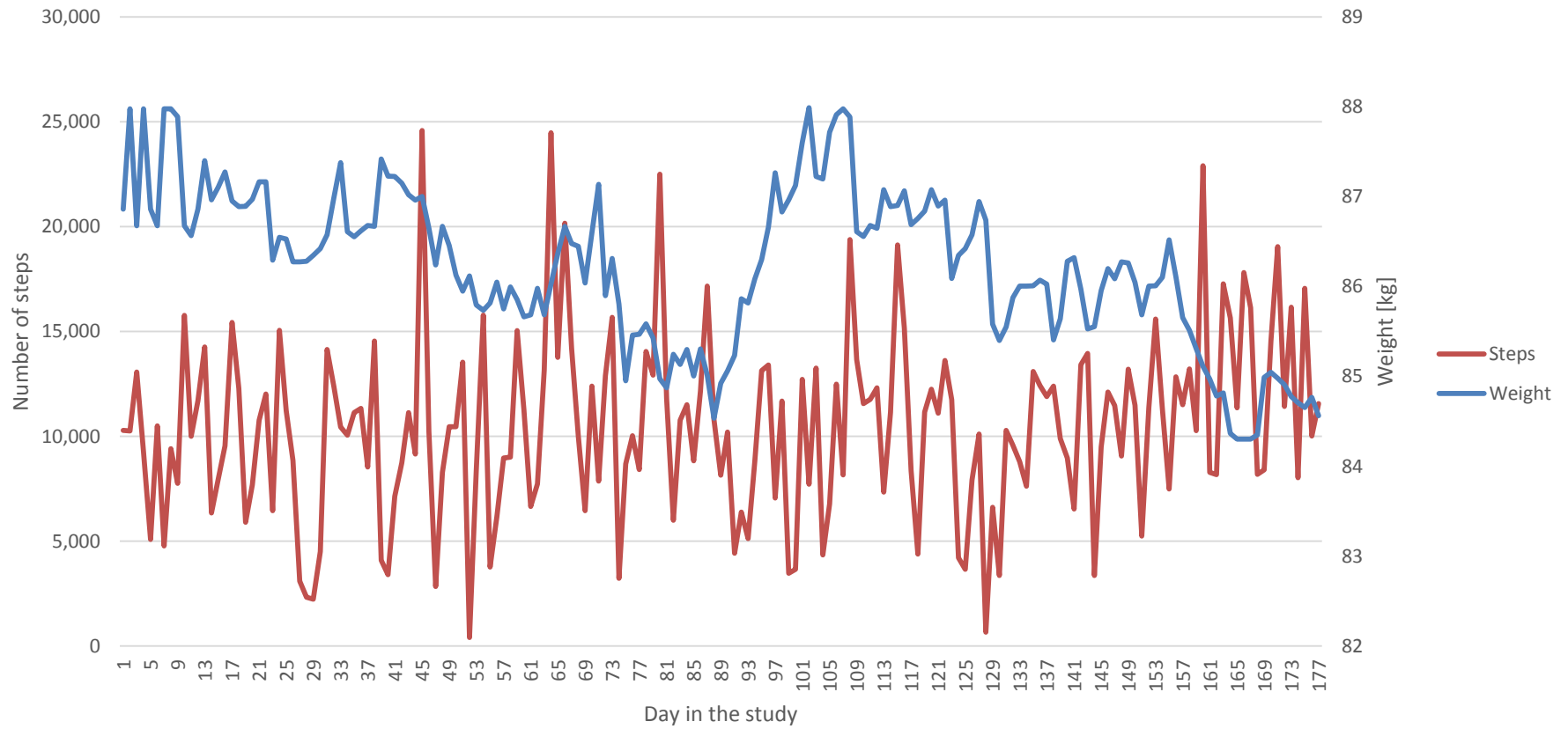
Figure 6: Number of steps and WLM plan adherence time plots for 12 study participants



## Participant 2

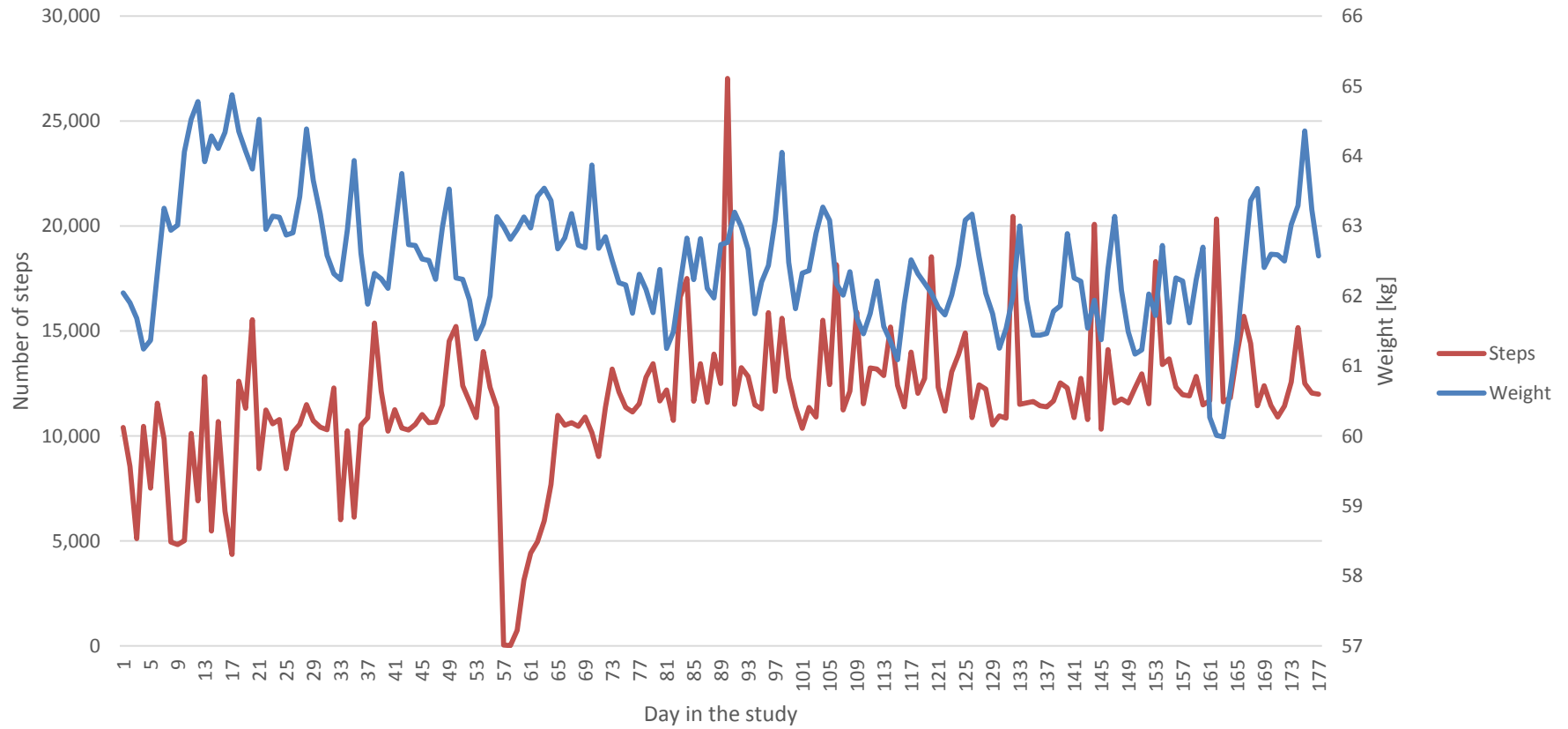


### Participant 3

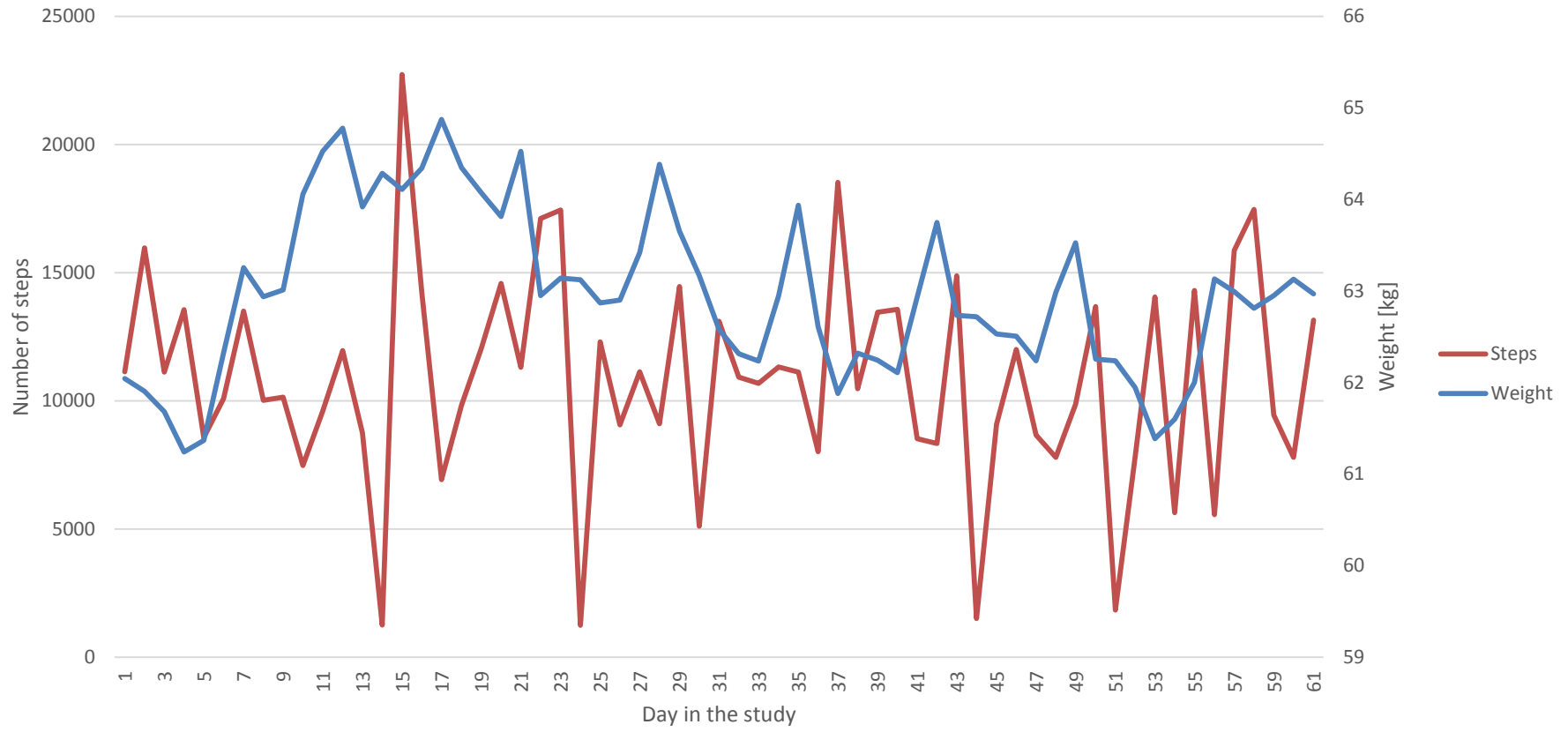




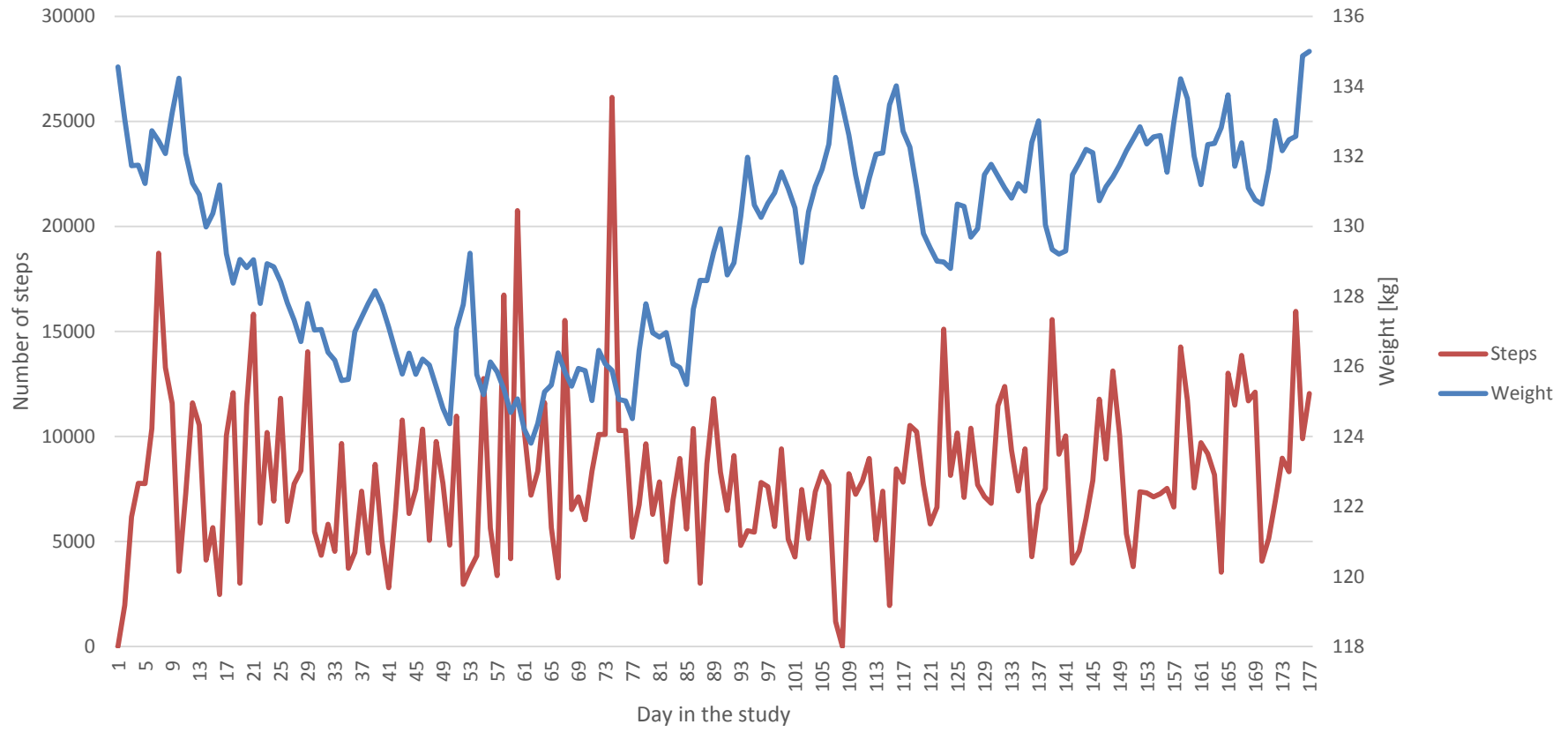
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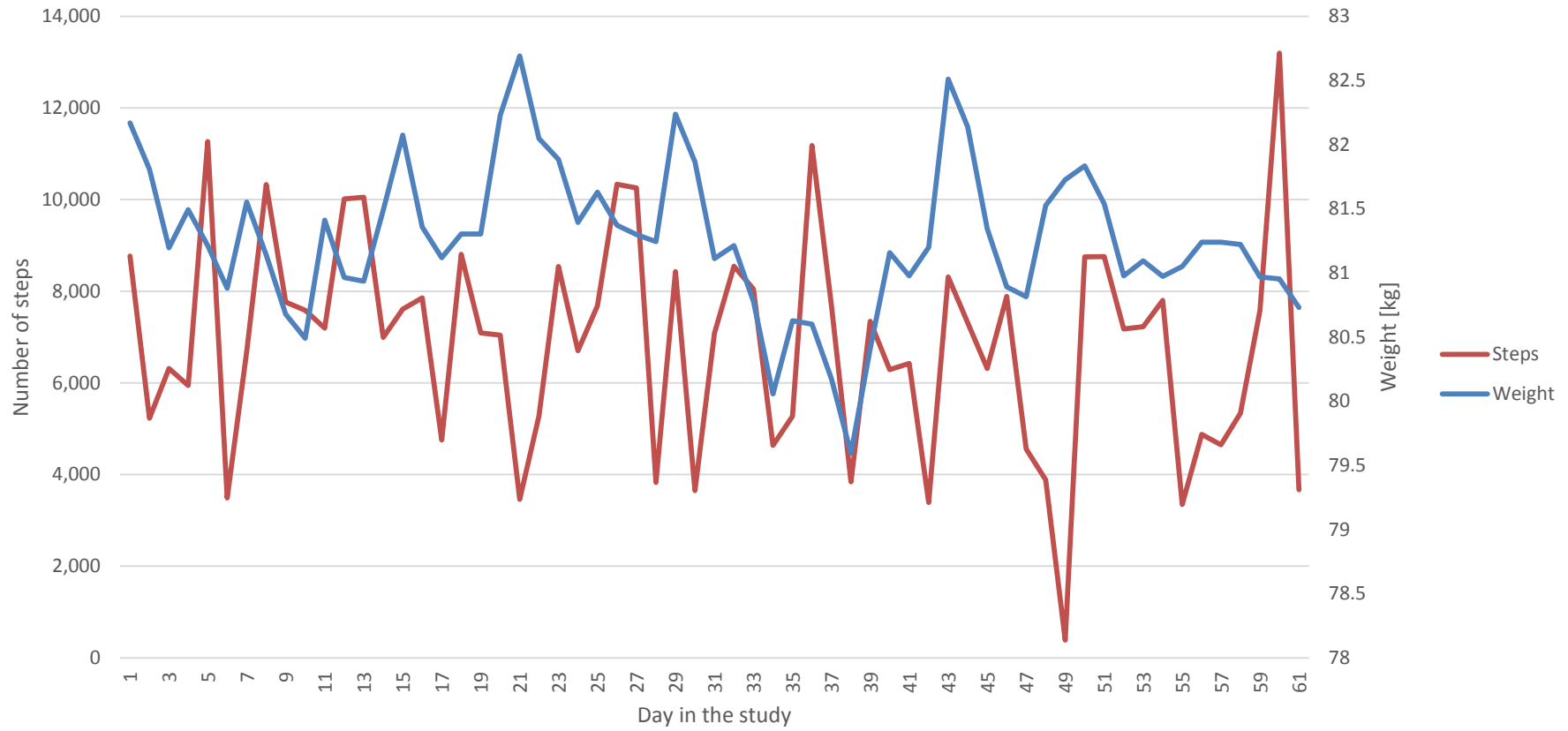
### Participant 5



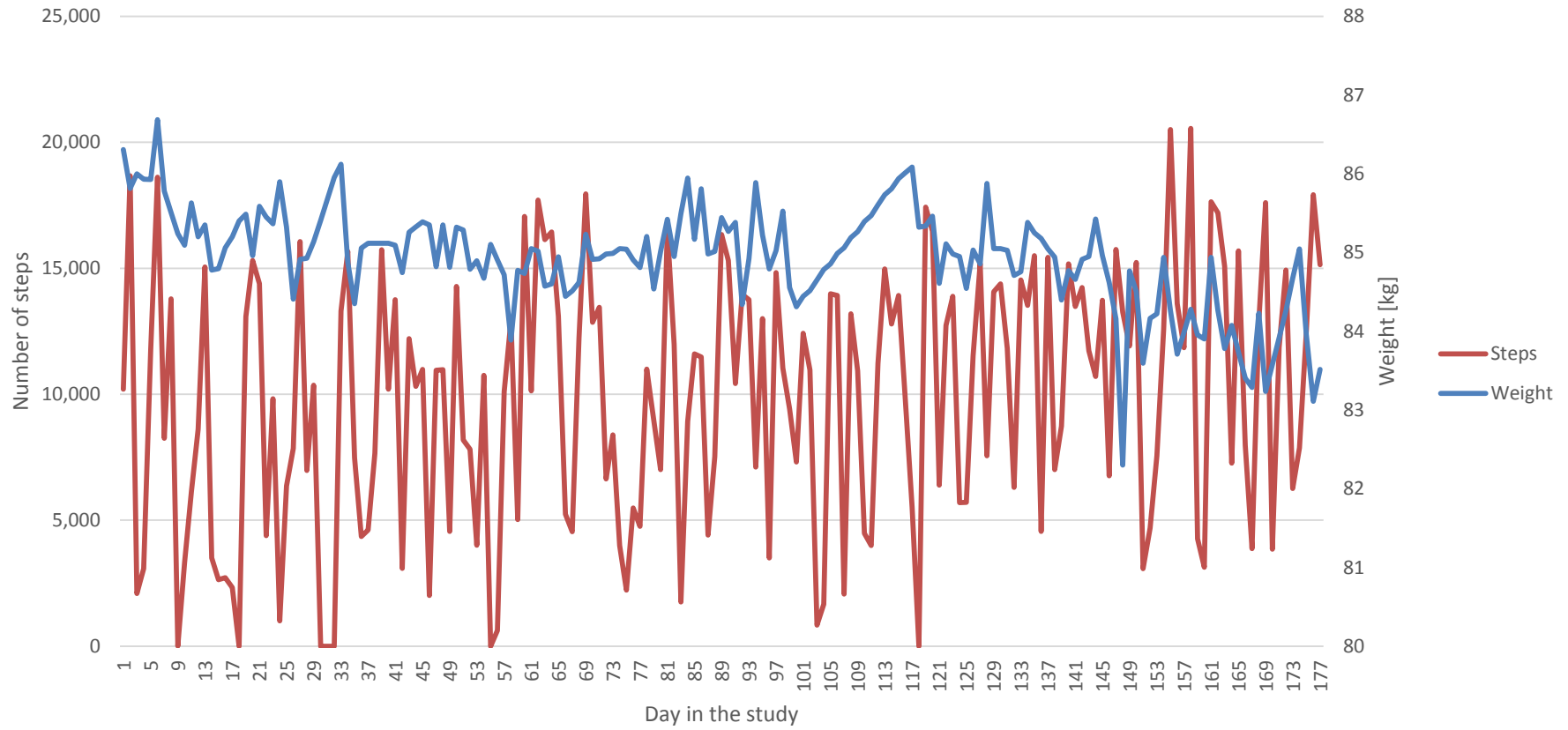
## Participant 6



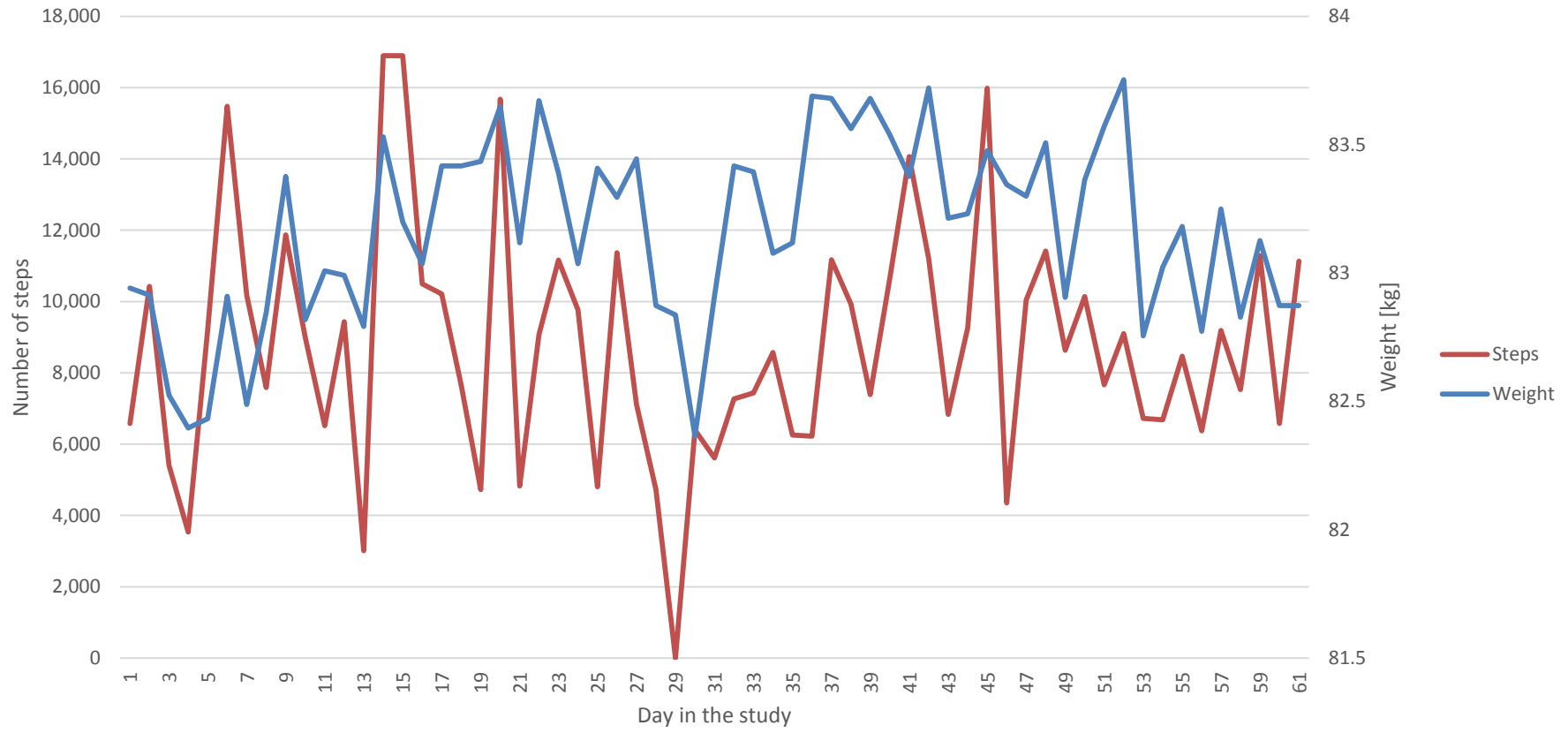
### Participant 7



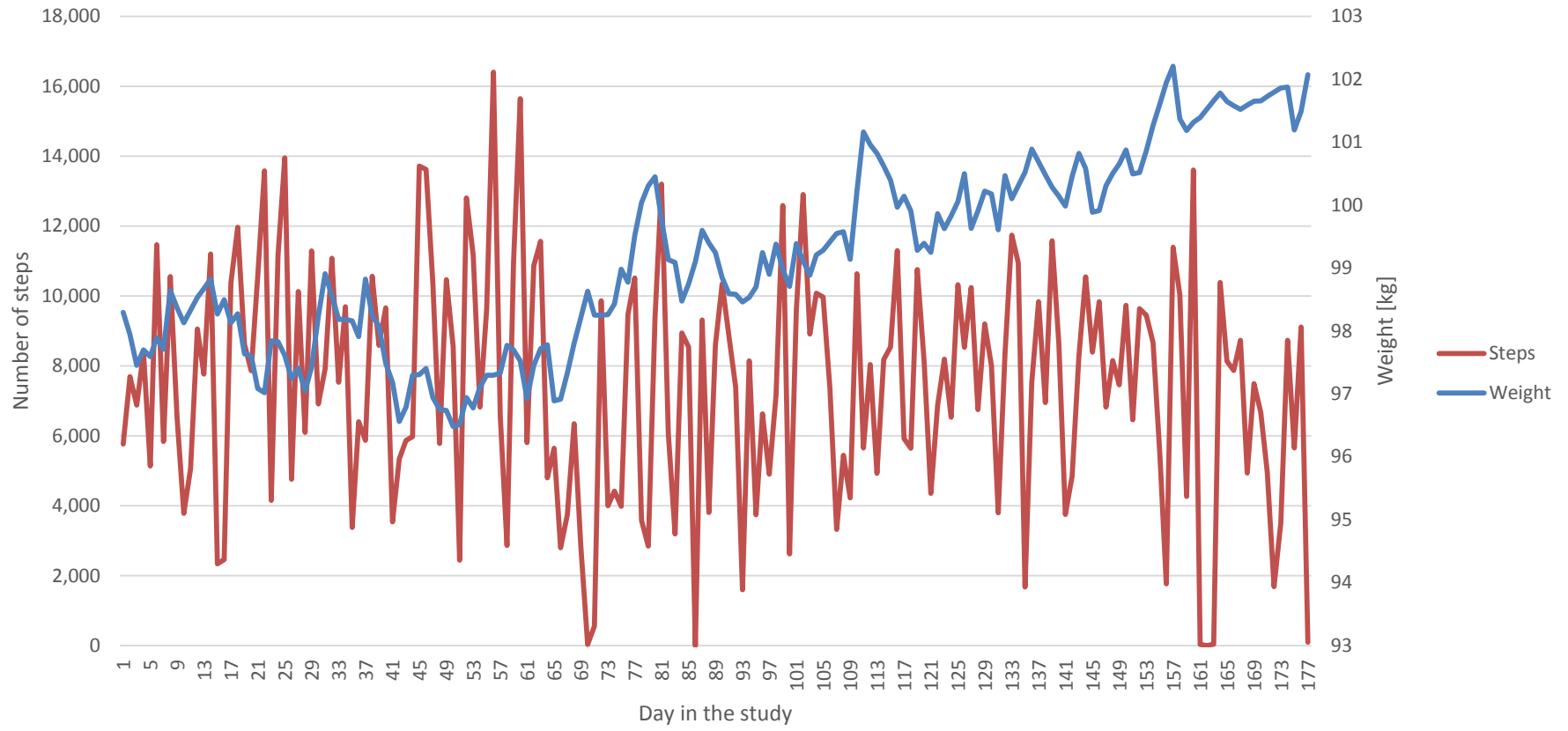
### Participant 8



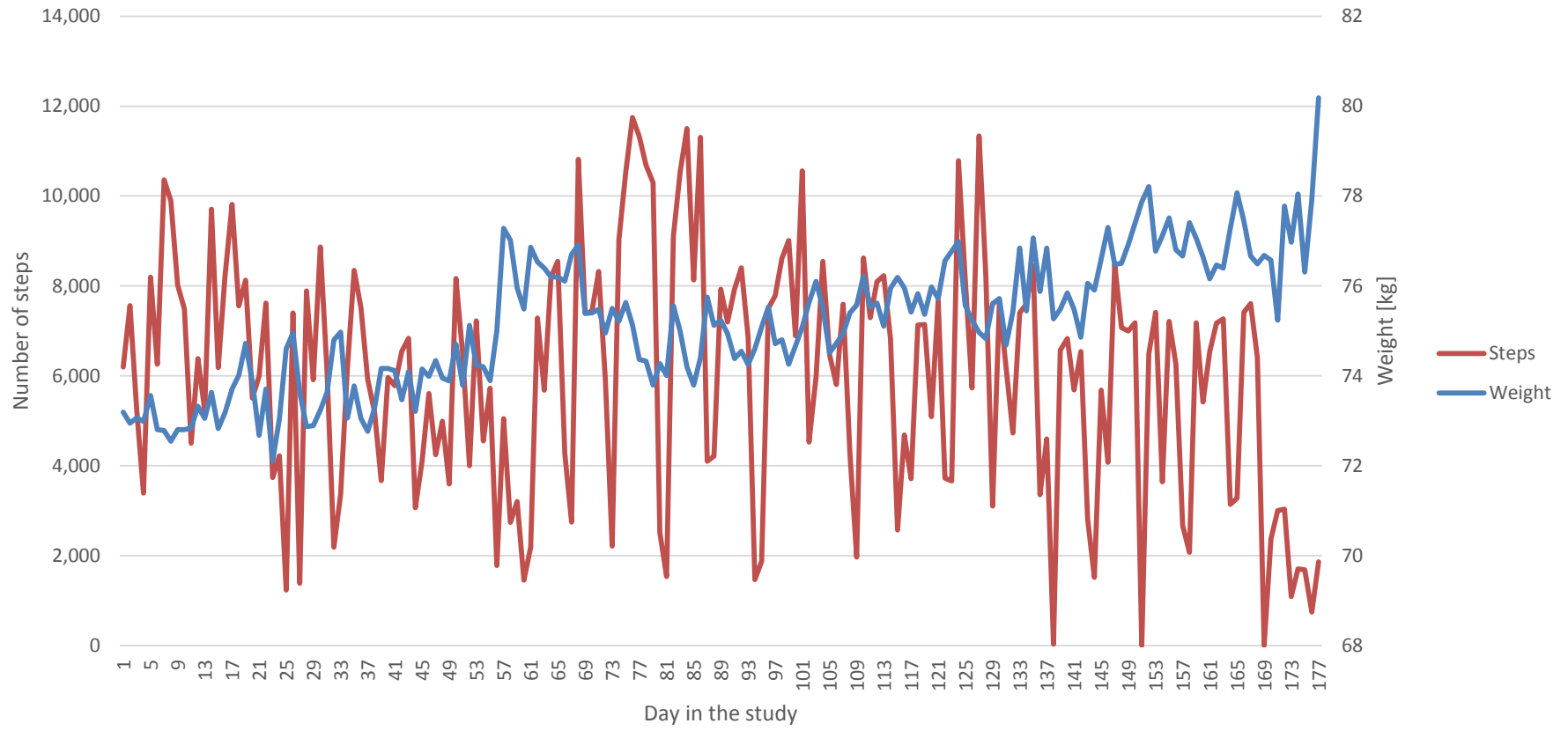
### Participant 9



### Participant 10



# Participant 11





### Participant 12

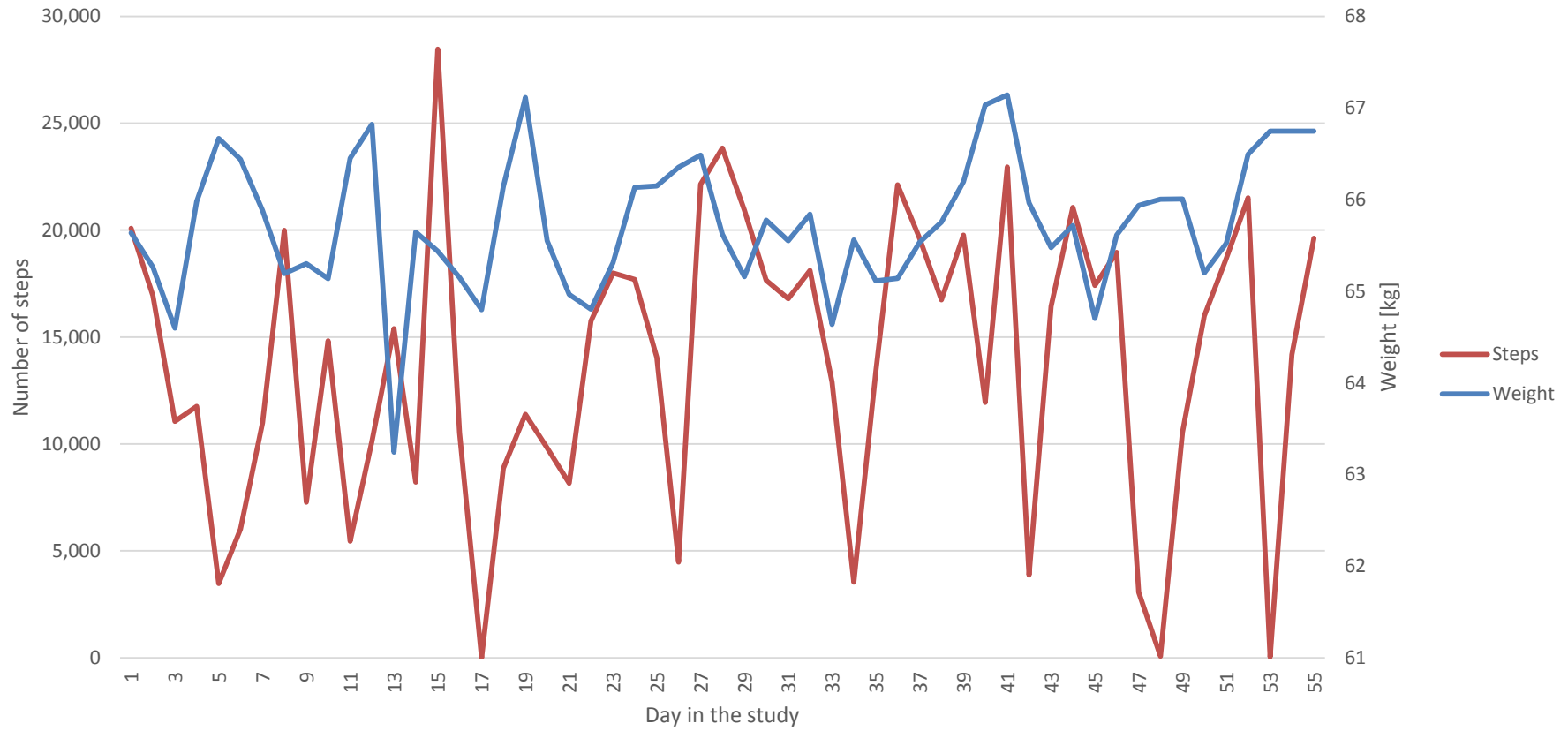


Table 9 Cross-correlations between step count and theoretical WLM variables

Theme	Motivation			Self-regulation					Habit	Resources				Environment		Other		
	Motivation	Importance	Benefits	Awareness	Obstacles	Confidence	Hunger	Temptation	Routines	Stress	Sleep	Energy level	Happiness	Context	Social support	Pain	Additional	Following plan
P1 (0.075)	.026	-.044	-.115	-.046	-.071	-.017	-.093	.036	-.165*	-.131	.062	.134	-.022	-.155*	-.144	na	na	.180*
P2 (0.076)	.232**	0.195*	.193*	.195*	.332**	.221**	.151	.266**	-.013	.162*	-.135	.523**	.220**	.318**	.123	.054	na	.338**
P3 (0.076)	.175*	.088	.005	.122	.289**	.148*	-.033	.200**	.445**	-.037	-.164*	.370**	-.035	.261**	.122	.015	-.210**	.316**
P4 (0.076)	.227**	.186*	.408**	.331**	-.163*	.183*	.147	.104	.363**	-.221*	.139	.631**	.320**	.251**	.383**	na	-.045	.395**
P 5 (0.135)	.240	.010	-.120	.188	.197	.340*	-.036	.096	.060	.278*	.356*	.067	.217	.165	-.110	-.078	na	.085
P6 (0.080)	-.080	-.045	.012	-.055	.153*	-.159*	.126	.145	.160*	-.001	-.034	.317**	.175*	.184**	.040	.169*	na	.146
P7 (0.135)	.051	.171	.168	.243	.355**	.217*	.265*	.210	.241	.155	.125	.330**	.220	.225	.125	na	na	.283*
P8 (0.071)	.142	.154*	.254**	.166*	.195**	.210**	.185**	.270**	.284**	.152*	.055	.592**	.152*	.190**	.241**	-.001	na	.294**
P9 (0.128)	.268*	.221	.080	.204	.314*	.341**	.169	.353**	.305*	.220	.198	.347**	.114	.196	.219	na	.126	.459**
P10 (0.081)	-.020	-.076	.146	.050	.092	-.046	-.132	.135	.032	-.136	-.342**	.456**	.052	.092	-.022	na	na	.134
P 11 (0.075)	.241**	.228**	.190**	.308**	.320**	.235**	.160*	.287**	.362**	.073	.028	.318**	.118	-.125	.008	-.168*	na	.255**
P12 (0.136)	-.122	-.137	-.245	-.009	.181	-.009	.165	-.085	-.264**	-.137	-.223	.452**	-.075	-.087	.081	.010	na	-.089

Notes. NA – not applicable; standard error for lag0 in brackets. \*\*Correlation is significant at the 0.01 level, \* at the 0.05 level (2-tailed); non-significant correlation – did not reach 95% CI

## 3.5 Discussion

### 3.5.1 Main findings

The psychological variables predicting WLM behaviours within individuals who have recently lost weight differ between individuals. Different models may apply and different interventions may be needed for different individuals; this suggests that there might be potential for stratified behavioural medicine. Patterns of theoretical variables of behaviour maintenance contributing to the prediction, and amount of variability accounted for, differed between participants for WLM plan adherence and physical activity. Different variables from each of the theoretical themes reported in the behaviour maintenance review (Chapter 2) were found to explain variability in outcomes in different individuals. Explanations for variables underpinning WLM demonstrated in this study *within* individuals are often in line with theory and with previous studies showing *between* person comparisons. Discussion of the results is presented subsequently for each theoretical theme: maintenance motives, self-regulation, resources, habit and environmental influences.

***Maintenance motives.*** For the majority of participants, sustained motivation was strongly correlated with WLM plan adherence in line with theory and previous between-person WLM studies (Elfhag & Rössner, 2005). Results for other motivation-related theoretical variables, namely satisfaction with behavioural outcomes (A. J. Rothman, 2000) showed a more complex pattern of results. Participants were not directly asked ‘how satisfied are you with your weight

outcome' to avoid participant dropout and study disengagement in case they were gaining weight and/or their daily satisfaction rates were low. Instead, participants were asked daily about appreciation of WLM benefits. This variable showed limited variability within participants and potentially it could be interpreted differently from satisfaction with outcomes.

Furthermore, participants were not asked about their identity changes, despite some theories emphasising that individuals are motivated to maintain behaviour congruent with identity values (Chapter 2). Previous studies suggest that identity change is usually linked to a singular event and it does not show day-to-day variation (Epiphaniou & Ogden, 2010), thus motivation related to identity values was not assessed. Overall, motivation to maintain weight loss was related to WLM for all apart from one study participant; importance of WLM and appreciation of WLM benefits were less predictive.

***Self-regulation.*** In line with several theories, active self-regulation including awareness of one's plan and goals is crucial for behaviour maintenance (Chapter 2). In all participants, awareness of a WLM plan significantly correlated with plan adherence. Empirical between-person studies have shown that people who actively self-regulate are more likely to maintain their weight loss (Elfhag & Rössner, 2005; Ohsiek & Williams, 2011) which is in line with the within person outcomes reported here.

Participants reported daily on the number of obstacles and temptations experienced and on how hungry they were. Obstacles and temptations showed

high correlations with WLM plan adherence. Results were in line with evidence suggesting that successful self-regulation is associated with the ability to overcome behavioural obstacles (G. A. Marlatt & George, 1984; Sniehotta et al., 2005). Hunger did not show significant correlations with following the WLM plan in most of participants. This finding was in contrast with previous studies that report hunger as an important predictor for WLM (Pasman, Saris, & Westerterp-Plantenga, 1999). Estimating and reporting hunger daily can be difficult as levels of hunger vary throughout the day; thus, future interventions could target temptation control rather than hunger reinterpretation.

**Resources.** This was the theme with the most limited predictive utility. In contrast with previous studies, our results did not show strong support for correlations between daily fluctuations of stress, pain and sleep with study outcomes in most participants. Although other studies report associations of these variables with WLM, they often present between-person comparisons for stress (DePue, Clark, Ruggiero, Medeiros, & Pera, 1995), pain (Larsson, 2003) and sleep (Beccuti & Pannain, 2011), associated with WLM and weight regain. Empirical studies (Klem, Wing, McGuire, Seagle, & Hill, 1997) suggest that having plentiful cognitive resources enhances WLM. Our research findings suggest that there are within person differences in the predictive utility of all three variables and further within- and between-person comparisons are needed to clearly define the relationships.

Two other variables within the resource theme were found to be predictive for some participants. Fluctuations of energy levels and happiness often correlated

with following the WLM plan. Energy level was correlated with step count in all apart from two participants. Happiness was strongly correlated with outcomes for some of the participants; in line with empirical studies that also show mixed results (Haedt-Matt & Keel, 2011). For instance a meta-analytic review of EMA studies of affect and binge eating has shown that positive as well as negative affect can trigger overeating (Haedt-Matt & Keel, 2011). Thus, effects were person specific, and being happy related to both success in following WLM plan and failure to follow it.

**Habits.** Relying on established eating and exercising routines correlated strongly with WLM plan adherence in all participants, with high correlations for most participants. For some participants, routine was also related to physical activity. Numerous studies have shown that creating eating and physical activity habits leads to successful WLM (Phillippa Lally, Chipperfield, & Wardle, 2007; Pronk & Wing, 1994). The presented findings provide the first evidence of the predictive utility of habit within participants in a WLM study. However, predictive validity might relate to the fact that only a single item measure was used to capture variability within this theme, as compared to up to five in other themes. Asking multiple questions might have diluted the effect or could have measured cross-correlated constructs. Conversely, asking multiple question relating to the same theme is sometimes reported as more reliable (Armitage & Conner, 2001).

**Environment.** Participants were asked daily how typical their environment was in relation to their WLM plan and typicality of the environment was usually correlated with WLM plan adherence. A supportive and stable environment was theorised as a

pre-condition for behaviour maintenance (Colin Greaves, Reddy, & Sheppard, 2012). Several studies have shown that people are more likely to maintain their weight loss if their environment is supportive and stable (T. Brown, Kelly, & Summerbell, 2007; Hill, Thompson, & Wyatt, 2005; Peters, Wyatt, Donahoo, & Hill, 2002). These findings are in agreement with the results from the reported study.

Social support was theorised as a part of the environmental context which also supports behaviour maintenance (Edward L. Deci & Ryan, 2010). Previous studies showed that successful WLM was often underpinned by social support (Elfhag & Rössner, 2005). *N-of-1s* reported here showed a variable pattern of results and a possible explanation for these findings may be the question wording. Variation in responses may relate not to the variability of the support received, but to the perceived need for social support. As demonstrated in other studies, there are various ways in which others can support a person's WLM, some of which may be more effective, e.g. encouragement compared to personally giving health warnings (Stephens, Rook, Franks, Khan, & Iida, 2010). Social support could be further investigated as a within-person factor in terms of need for social support and amount of support received. For both measures assessed within this theme, only single item measures were used, so problems related to single item measurement could potentially also play a role here.

### **3.5.2 Study strengths**

The main study strengths were use of explicit theoretical themes, the *N-of-1* design, and novel combination of methods and technology deployment. Predictors of

outcomes tested in the study were based on the systematically reviewed theories. Each of the theoretical predictors was derived from the theory review which systematically analysed explanations of behaviour maintenance (Chapter 2). Multiple predictors of outcomes were assessed to examine the applicability of the theory at the within-person level. Some of the theories and explanations have been previously tested between people, but none have been reported for within-person comparisons in WLM research.

Variables predicting differences between individuals are often different from variables that predict differences within individuals measured at different time points (Craig et al., 2008; Johnston & Johnston, 2013). The *N-of-1* design allows examination of maintenance related themes within people for the predictions which already had been tested and reported at the between person level. This was the first study to assess WLM predictors in a within person design. This study showed that WLM behaviours and their theoretical determinants vary considerably over time within individuals.

Novel technologies were used to collect data in real-time. Applying cost effective technology in the form of pre-scheduled text messaging system and participants' own device of choice (Smartphone, tablet, computer) allowed efficient data collection. Participants' answers to daily questionnaires were time-stamped allowing assessment of the exact timing of survey completion; participants were not able to go back and modify previous surveys. Moreover, validated and reliable Wi-Fi connected scales and activity monitors were used (Takacs et al., 2013) to



receive objectively measured real-time outcome data. The researchers were able to monitor equipment use and battery levels remotely and were also able to remind participants to use the equipment if they forgot to use it or wear it, or if the battery levels were low; this promoted high levels of compliance with the study protocol.

### **3.5.3 Study limitations**

Study limitations included practical and technical challenges. Despite the fact that this study was designed to be purely observational, it also included several BCTs (i.e. self-monitoring, using prompts and reminders) thus participants' behaviour could be potentially altered by daily assessment. Although a recent systematic review of the question-behaviour effect has shown that the effect of asking participants questions on changing their behaviour is not conclusive (Rodrigues, O'Brien, French, Glidewell, & Sniehotta, 2014), engaging in several study activities could potentially impact on study outcomes. For example, asking participants daily questions regarding their WLM-relevant predictors and outcomes, and asking them to use devices to monitor physical activity and weight, may have altered participants' behaviour and acted as an intervention.

Furthermore, the study sample consisted of highly motivated individuals, and the majority continued on the study for up to six months, daily answering research questions. Initial high motivation might have an impact on study results and potentially a different pattern of results would be observed in a less motivated study sample.

Moreover, compliance with using the scale could not be assessed objectively as the wireless scales used an algorithm to input missing weight values that are presented to scale users. However, participant interview accounts suggest very high daily compliance with using the scale.

#### **3.5.4 Study implications**

This study has potential implications for research, policy and practice. This study showed that *N-of-1* design is valuable to test if predictions demonstrated between people also hold within individuals. It has been shown that not only one-off tests of predictions but also assessment of trends, changes and variations in cognitions helps to test hypotheses about health-related behaviour. Using *N-of-1* is resource intensive and it requires repetitive assessment of individuals. This study demonstrated that using wearable devices and providing participants with multiple convenient ways to answer study questions increases response rate and compliance with study protocol.

The results reported are in line with existing national policy (Butland et al., 2007; Department of Health, 2011a) showing that behavioural interventions need to tap into relevant behavioural explanations and deliver timely intervention components to support WLM. Maintenance of significant weight loss is challenging (Avenell et al., 2004; Curioni & Lourenco, 2005) and supportive WLM interventions should tackle several variables which were assessed in this study. The study demonstrated that motivating people to self-regulate their weight, to develop healthy eating and activity habits, and changing environmental context would help individuals

maintain their weight long term. Interventions should be customised and adaptable to time-specific personal needs.

One challenge faced by behavioural interventionists is that lifestyle change and maintenance is underpinned by many variables. These variables include cognitions, which continuously change the degree to which they impact on behaviour. Repeated assessment of the variables underpinning behaviour change maintenance allowed assessment of the relationship between the predictors and outcomes, thereby uncovering the strongest correlations.

Variables underlying maintained weight loss are inter-related and often multiple variables play a role. This study showed that variables influencing WLM outcomes vary within people and that they change with time. Thus, in practice a time specific and tailored approach is needed to design effective interventions helping people to develop healthy lifestyles and maintain healthy weight. The concept of tailoring goes beyond building interventions based on pre-defined stages and algorithms; it includes elements of customisation and choice based on person-specific needs and prior assessments.

### **3.5.5 Unanswered questions and future research**

Some suggestions can be made regarding future research including study design, and data analysis. Future research should not only test explanations and predictors of WLM, but could also intervene on the predictors which are shown to be significant. Future studies may base tailoring of interventions on the cognitions that

show the strongest associations with outcome variables. Gathering *N-of-1* data allows current interventionists to concentrate on specific predictors which are shown to have the most powerful influence on self-reported outcomes, activity and weight changes. Combining wearable technology, social media and other platforms, would allow for real-time intervention which is modelled and tailored according to behaviour predictions (Gilmore et al., 2014), e.g. providing social support via social media when low on confidence, or enhancing awareness when routines change if a person's WLM plan adherence is reactive to unstable environments.

In the present study, the assessed sample consisted of people whose average age was above 50 years old. In the era of digital adoption, SmartPhones and wireless devices are becoming more widely available, and more popular among people of all ages (Gilmore et al., 2014). Therefore, future research should explore the differences in study adherence and technology use between younger and older participant groups.

There are several psychological trait factors (e.g. optimism, neuroticism, psychological flexibility, and resilience) that are likely to influence WLM outcomes (Linde et al., 2004; Sutin et al., 2011). These traits were not assessed and described in this study; however, future research could explore the influence of specific traits on WLM outcomes. The stability of individual personality traits and individual skills related to behaviour maintenance may influence initial weight loss and then further impact on the trajectory of weight regain. Skills such as planning, impulse

management and self-control differ between individuals and developing and implementing these skills may be an additional determinant related to the WLM.

Many minor and major life events might have impacted on participants WLM. Such events were often captured in participants' notes; however these were not analysed quantitatively. Minor life events included birthday parties, business trips, and other social occasions when participants were often less likely to adhere to their WLM plan. Major life events included redundancy threat or important exams which often have prolonged effects on participants' WLM plan adherence. Future studies could also assess minor and major life events in relation to temporary and prolonged WLM plan adherence.

Time series analysis produces vast amounts of data and there is no established consensus on how to best analyse *N-of-1* studies (Shamseer et al., 2015). Researchers reporting *N-of-1* outcomes often treat each of the participants as a separate study; here outcomes for twelve participants have been summarised in one study. Presenting each participant as an independent study would allow assessment in more detail of changes and trends in each of the predictors and their relationship with each of the outcomes (Pindyck & Rubinfeld, 1998).

Moreover, further studies could compare single and multiple item measures per each theme and investigate if the number of questions asked per theme affects the strength of the correlations observed.

### **3.6 Conclusions**

Our findings suggest that different predictors are important for WLM in different individuals and the variability of predictors and their impact on behaviour needs to be considered. The presented findings highlight the usefulness of *N-of-1* design to test theory to explain individual behaviour. Previous studies presented outcomes aggregated across participants explaining differences in WLM between people. To design effective interventions it is crucial to understand not only between, but also within person differences. Cognitions underpinning successful WLM are likely to vary over time, thus better understanding of when people are more likely to successfully maintain their weight is needed.

### **3.7 Link to other chapters**

This chapter summarised *N-of-1* study assessing individual and contextual predictions of WLM within individuals. Participants in this study took part in the data-prompted interviews at 2 and at 6 months. Their *N-of-1* data including weight and activity graphs, correlations of predictors and outcomes and other qualitative data (comments, and pictures) were presented to them during the interviews. Chapter 4 describes the novel method of data-prompted interviews and the advantages and challenges associated with this method. Chapter 5 includes details of the data-prompted longitudinal qualitative study, with *N-of-1* study participants, investigating their experiences of WLM.

### **3.8 Chapter acknowledgements**

Thank you to Dr Nicki O'Brien, Professor Derek Johnston and Dr Francis Quinn for their comments and suggestions regarding *N*-of-1 data analysis. Thank you to Dr James Newham for providing comments on the chapter and suggestions for how to present study data.

## Chapter 4 Data-prompted interviews: using individual ecological data to stimulate narratives and explore meanings.<sup>5</sup>

### 4.1 Abstract

**Background:** An emerging trend in qualitative research is to use individual participant data to stimulate narratives in interviews. This chapter describes the method of the data-prompted interview (DPI) and highlights its potential benefits and challenges.

**Method:** DPis use personal ecological data gathered prior to the interview to stimulate discussion during the interview. Various forms of data can be used including photographs, videos, audio recordings, graphs and texts. This data can be gathered by the researcher or generated by the participant and may utilise ecological momentary assessment.

**Findings and Discussion:** Using individual data in DPis can stimulate visual and auditory senses, enhance memory and prompt rich narratives anchored in personal experiences. For the researcher, DPis provide an opportunity to explore the meaning of the data and to explain data patterns. For the participant, presented stimuli give guidance for discussion and allow them to reflect. The challenges associated with conducting DPis include practical issues such as data selection and

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presentation. Data analyses require narratives to be interpreted together with the data. Ethical challenges of DPI include concerns around data anonymity and sensitivity.

**Conclusions:** Combining various sources of data to stimulate the interview provides a novel opportunity to enhance participants' memories and to meaningfully assess and analyse data patterns. In the context of health promotion and illness prevention DPI offers a unique opportunity to explore reasons, opinions, and motivations for health-related behaviours in the light of previously gathered data.

**Keywords:** data-prompted interview; ecological momentary assessment; qualitative methods

## **4.2 Introduction**

### **4.2.1 Data-prompted interview: definition and aims**

Data-prompted interviews (DPIs) use personalised prompts such as photos, videos, audio recordings, graphs and texts to stimulate discussion in a qualitative interview setting. In line with other qualitative research methods, DPIs are primarily explanatory and are used to generate in-depth understanding of human behaviours and experiences, taking into account complexity, detail and context (Spencer, Ritchie, & O'Connor, 2003). Qualitative interviews can be defined as a 'conversation with a purpose' (Gerard Sister, 1959); DPIs may add depth to this conversation. The three main aims of DPIs are:

1. To actively stimulate and guide the discussion using data driven prompts

2. To explore, integrate and contrast interpretations derived from data with participant's experiences and narratives
3. To discuss and evaluate participants' views towards the personal data presented.

DPIs can be solely qualitative (e.g. photographs discussed in the DPI) or they can use a mixed method approach (e.g. combining quantitative measures gathered prior to the interview with DPI)<sup>6</sup>.

## 4.3 Methods

### 4.3.1 Data-prompted interview: sources of data

DPIs use various sources of data to stimulate discussion during an interview. In this section three common sources of data are discussed, namely (1) photographs, (2) video or audio recordings, and (3) graphical representations. However, other sources can also be used, for instance material objects, e.g. home possessions (Miller, 2008) and artworks (Radley & Bell, 2007).

**1. Photographs** are used in interviews through photo elicitation and visual storytelling. Photo elicitation is a qualitative research technique which uses a photograph to stimulate a discussion (Harper, 2002). For example, an individual trying to lose weight could take photographs of key motivators and barriers to their everyday weight loss attempts. In visual storytelling participants are encouraged to

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<sup>6</sup> This chapter focuses on one-to-one interviews. However, data prompted discussion can also take place in focus groups (for instance: Cooper & Yarbrough, 2010) and most of the DPI characteristics described in this chapter also apply to data-prompted focus groups.

tell a story that emerges from the sequence of pictures (Drew, Duncan, & Sawyer, 2010). Photographs have been used in interviews to extend and elaborate on memories and evoke emotions (Clark-Ibanez, 2004; Harper, 2002), to stimulate enriched narratives about health-related experiences, e.g. living with illness (Bell, 2002) or experiencing poverty (Hodgetts, Radley, Chamberlain, & Hodgetts, 2007).

Images are processed faster than verbal cues and they evoke different brain regions (Harper, 2002). Photo elicitation covers a range of approaches; e.g. asking participants to proactively take pictures documenting specific issues or experiences, discussing relevant photos already taken by participants, as well as elaborating on photos provided by the researcher. Photo elicitation facilitates data collection among harder to research groups, such as children (Drew et al., 2010) and indigenous communities (Samuels, 2004), as it can be easier for them to express themselves through photographs than through words. For some studies, photo elicitation has been found to be more appropriate than other forms of data collection. For instance, photo elicitation was more effective than daily diaries in collecting data on self-management of diabetes; participants enjoyed capturing information in pictures but they did not adhere with a daily diary (M. Thompson & Oelker, 2013).

**2. *Video or audio recordings*** are employed in DPs through video- or audio-elicitation; in video- or audio-elicitation studies, recorded visual and audio material is used to initiate and focus the discussion during the interview (Coleman, Murphy, & Cheater, 2000; Gao, Burke, Somkin, & Pasick, 2009; Saba et al., 2006). For

instance, recording of a physician and patient interaction can be used as a tool to stimulate a discussion about the encounter (for a good overview of the topic see: Henry & Fetters, 2012). Video elicitation can be also used for teaching purposes (C. Chou & Lee, 2002) or as a health intervention tool (Harms et al., 2004). Video elicitation can be used to aid memory and to gain insights into thoughts, emotions and beliefs regarding the recorded situation. Video-elicitation studies with children suggest that film is a powerful tool to enable young people to meaningfully engage in health research (Bissell, Manderson, & Allotey, 2000). Video diaries are particularly suited to research with people from vulnerable groups giving them tools to express their shared viewpoints, e.g. recording situations relating to shared community issues that affect health (C. Brown, Costley, Friend, & Varey, 2010). Video and audio elicitation aids memory and the interview gives the participant an opportunity to reflect on the recordings.

**3. Graphical representations** including graphs, diagrams, statistics, and maps can be used as stimuli in interviews. Several forms of graphical representation can be used to evoke discussion. For instance a 'life grid' is a visual tool used for mapping important life events against a time period to construct and reflect on a participant's life story (Wilson, Cunningham-Burley, Bancroft, Backett-Milburn, & Masters, 2007). Another example is 'chart-stimulated recall', a technique that uses hospital patient charts to probe physician recall and provide context about barriers and facilitators to effective care (Guerra, Katrina Armstrong Md, & Brown, 2007). Diagrams are effective instruments in conveying complex thoughts to others; they

often show relationships and concepts that are difficult to explain verbally (Crilly, Blackwell, & Clarkson, 2006). Using graphical representations in interviews was reported to be helpful while discussing sensitive issues (Kesby, 2000; Wilson et al., 2007) and while conducting research with children (Bagnoli, 2009; Young & Barrett, 2001). Multiple health-related studies have employed graphical representations of data to stimulate discussion (e.g. Kesby, 2000; Wilson et al., 2007). Graphical representations often involve higher levels of mental processing and can provoke and facilitate discussion which might have been too complex without a visual prompt.

**4. Mixed sources of data:** DPIs can draw on multiple different sources and types of data. A study examining disabled young men transitioning to adulthood, for instance combined audio diaries and photography, using them in interviews suggesting that participants' acts of gathering data (data creation) are analysable events in themselves (Gibson et al., 2013). Another example is 'timelining', a method developed in the context of weight management research (Sheridan, Chamberlain, & Dupuis, 2011). In this research participants' weight over time was plotted on a graph and elaborated on by a variety of stimuli such as photographs, medical records and personal diaries. The timeline was used as a prompt in the interview to document, record and extend understanding of participants' experiences, encouraging rich temporal narratives (Sheridan et al., 2011). A growing body of qualitative health research uses photos, videos and graphics to stimulate

the discussion, some studies combine more than one data source (Gibson et al., 2013; Sheridan et al., 2011).

#### **4.3.2 Data generation**

There are two main data generation categories: researcher created data and participant created data (Prosser & Loxley, 2008). Data presented to the participant can be captured automatically, e.g. with accelerometry or with GPS measures (Oliver, Badland, Mavoa, Duncan, & Duncan, 2010). Data can also be gathered by a participant through Ecological Momentary Assessment (EMA). EMA involves repeated assessment of an individual's behaviours and/or experiences in real-time, in their natural environment (Saul Shiffman et al., 2008). EMA often involves prompting participants at random and/or pre-specified times and asking them to collect the data (e.g. take a picture, make a video, answer questions). EMA can also be used in *N*-of-1 research designs where hypotheses about relationships between variables (Quinn et al., 2013) or responses to interventions (Sniehotta et al., 2012) can be tested at the individual level. Data gathered through EMA is subsequently used in the interview.

EMA can be participant-initiated or researcher-initiated. For instance participants of a smoking cessation study were asked to report any episodes of smoking as they happened and were asked to complete a brief assessment of their craving, mood and context during the episode (participant-initiated assessment). In addition, participants received a similar assessment at random times during the day (researcher-initiated assessment) (S. Shiffman, 2005). Data generation methods

vary depending on who generates the data, how and when it is gathered and subsequently how is it used for an interview. EMA can identify levels and changes in measures within the individual (for example in weight or mood) or relationships between measures (e.g., relationships between pain and physical activity over time). This creates novel and highly personalized stimuli in interviews as participants might not be aware of these relationships before being presented with the EMA results.

## **4.4 Results and Discussion**

### **4.4.1 Benefits of DPI**

There are various benefits and some potential challenges of DPIs. DPIs use prompts to trigger discussion by stimulating verbal, visual and auditory senses. The presentation of the stimuli evokes various brain regions involved in non-verbal information processing, including specific brain regions which play a role in memory, attention, logical analysis and processing emotions (Kandel, Schwartz, & Jessell, 2000). DPIs evoke memories; participants are presented with data which stimulates discussion and encourages reflection (Clark-Ibanez, 2004; Harper, 2002; Henry & Fetters, 2012). DPIs provide unique opportunities to clarify and evaluate the meaning of the data and to discuss thoughts and emotions underlying the data (Sheridan et al., 2011). This refers to thoughts and feeling stimulated about the data during the interview and those represented by the data when it was generated. If the data used for DPIs is covert to the participants then their expectations regarding the data can be explored.

There are also several advantages of DPIs for research participants. Data provides topics and direction for discussion and it serves as a point of reference for interview questions (Sheridan et al., 2011). DPIs provide an opportunity for researchers and participants to co-produce knowledge, exchange perspectives and agreeing an interpretation. In the context of health-related behaviours such as smoking, drinking, binge eating, changes in perceptions or single events of relapse can easily be forgotten. Enhancing participants' narratives with data prompts gives health researchers a unique opportunity to gain a broader understanding of underlying health-related cognitions and contexts. Data can be used as a persuasive presentation tool. Knowledge gained through DPI can also inform future health interventions, e.g. enhancing shared decision making in health settings.

#### **4.4.2 Potential challenges of DPI**

There are some potential practical, analytical and ethical challenges in using DPIs. Practical challenges relate to the data selection process. Data needs to be carefully selected (Harper, 2002; Henry & Fetters, 2012) and clearly explained to the participant. Analysis of DPI data can be challenging as prompts need to be stored together with the interview recording. Data need to be analysed and interpreted in conjunction with the interview narratives. Some ethical challenges also need to be addressed before the interview concerning data anonymity and sensitivity. Participants need to consent to gather and discuss data they are presented with. Data gathered can include personal and sensitive information regarding participants and their contexts. Other people may inherently be part of the



generated data (e.g. spouses of participants), so they also need to consent to appear on the pictures or videos; lack of consent may prevent analysis and publication. Vulnerable groups have been reported as receptive and easy to collaborate with in data-prompted research (C. Brown et al., 2010; Drew et al., 2010). Nevertheless, special ethical challenges, such as parent/carer consent, should be addressed while working with these groups.

## **4.5 Conclusions**

In qualitative interviews participants refer to their beliefs, insights and awareness at the time of the interview. Participants' narratives are based on memories which are often limited. Using data as stimuli for an interview can enhance memory and allow a high level of participant-led involvement in health research, as well as providing stimuli for eliciting further verbal material. DPI as a research method has a potential to enhance the understanding of health-related issues and to intervene changing health-related behaviours.

## **4.6 Link to other chapters**

This chapter described a novel method of data-prompted interviews. The following chapter applies this method in people who have successfully lost 5% of their body weight in the year prior to the study. The following chapter provides an example of interview prompted by mixed data. Throughout the *N-of-1* study (Chapter 3) participants were encouraged to write comments and take pictures documenting situations that relate to their weight management. At the interview participants are

presented with the report including their weight and step count graphs, with averages for each cognition assessed through EMA, cross-correlations of predictions and plan adherence, and with their comments and pictures divided into themes. At the DPI participants are presented with data which is overt (e.g. pictures that they have provided) and data which is covert to them (e.g. correlations of predictors and outcomes captured through EMA). They are encouraged to discuss their experiences of WLM in relation to the presented data.

#### **4.7 Chapter acknowledgements**

Thank you to Dr Tim Rapley and Dr Amy O'Donnell for their comments on the early draft of this chapter.

## **Chapter 5 A longitudinal data-prompted interview study of weight loss maintenance experiences in people who have lost weight.**

### **5.1 Abstract**

**Background:** Weight loss programmes are effective in supporting individuals to achieve clinically significant weight loss, but long term WLM is rarely attained. Previous qualitative studies have explored characteristics of weight loss maintainers, however they have not combined personal WLM data gathered prior to the interview with the narratives. This study aimed to advance understanding of the individual and environmental factors underpinning WLM.

**Methods:** Semi-structured, data-prompted interviews were conducted with adult participants of the *N-of-1* study who lost over 5% of body weight in the previous year. Participants were interviewed after two months and six months. Prior to the interviews, participants gathered WLM relevant data through ecological momentary assessment and experience sampling. During the interviews, each participant was presented with a report based on their own data including weight and activity graphs, correlations of psychological factors, self-generated notes and pictures. Data were analysed using the Framework method, applying pre-specified maintenance-relevant themes derived from the theory review.

**Findings:** Twelve participants were interviewed (3M, 9F) after two months and eight (2M, 6F) after six months. The theoretical framework was a good fit with the

narratives, with five main themes underpinning successful WLM: sustained maintenance motivation; effective self-regulation; plentiful cognitive resources; habit formation; and a supportive environment. Participants reported an identity shift from being a dieter to accepting a new healthy lifestyle. Using participants' data summaries and repeated interviews proved valuable in evoking narratives regarding personal experiences of WLM.

**Discussion:** Participants elaborated on the five main themes which related to successful WLM. Each theme related to existing theoretical explanations and can be linked to effective WLM strategies. This study successfully used the novel method of data-prompted interviews to explore WLM. Future research should further develop theory and data-prompted interview methods, and explore which combinations of strategies are most effective in helping people maintain weight loss.

**Keywords:** behaviour maintenance theory, data-prompted interviews, ecological momentary assessment, experience sampling, weight loss maintenance

## **5.2 Introduction**

### **5.2.1 Weight loss maintenance**

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair an individual's health (World Health Organization, 2015d). Excessive body weight is the fifth leading risk for mortality worldwide, with at least 2.8 million adults dying each year as a result of being overweight or obese. Moreover, 44% of

diabetes, 23% of ischaemic heart disease and 7% to 41% of certain cancers are attributable to being overweight or obese (World Health Organization, 2015d). The disease burden due to inappropriate dietary patterns and physical inactivity is high in Europe, with an increasing trend in most countries (World Health Organization, 2015a). In England, 62% of adults are overweight or obese, and health problems associated with excessive body weight costs the NHS over £5 billion every year (Department of Health, 2014). It is currently a public health priority to promote healthy diet and reduce inactivity at the population level (Butland et al., 2007).

An array of evidence shows that behaviour change interventions are effective in supporting individuals in their initial weight loss (Franz et al., 2007; Jolly et al., 2011). However, one year following this initial weight loss, individuals on average regain nearly half of the lost weight, and after 3-5 years most have fully regained or exceeded their previous weight (Avenell et al., 2004). Preventing regain of weight and promoting further weight loss, if needed to achieve a healthy weight, is therefore crucial in targeting obesity. Weight loss of 5% of body weight and above is considered to lead to clinically significant levels of health improvement (Franz et al., 2007). WLM in this study is defined as the ability to continuously sustain body weight after an intentional initial weight loss, at a level that significantly differs from the baseline weight (5% and more) in the intended direction.

### **5.2.2 Theoretical explanations for behaviour change maintenance**

Theoretical explanations for maintenance of behaviour change have been summarised in a comprehensive review of 100 behaviour theories (Chapter 2). In

this study, the key theoretical explanations for behaviour change maintenance identified in this review were applied to the subject area of WLM. The explanations examined include: maintenance motives; effective self-regulation; plentiful cognitive resources; habit formation; and a supportive environment. A summary of the maintenance-relevant themes and their implications, derived from the theory review, is provided below (see Chapter 2 for details).

People tend to maintain their behaviour if they are motivated, i.e. they are satisfied with behaviour outcomes (A. J. Rothman, 2000; A.J. Rothman et al., 2004), they enjoy engaging in the behaviour (E. Tory Higgins, 2005), or if their behaviour is congruent with their beliefs and identity (Bracken, 1996). In line with dual process models (Strack & Deutsch, 2004) reflective and impulsive processes underline behaviour change maintenance. People maintain behaviour if they successfully self-regulate their actions (Peter A. Hall, 2013; P.A. Hall & Fong, 2007), and if they have effective strategies to overcome barriers to performing the new behaviour (Sniehotta et al., 2005) and to deal with relapse (G. Alan Marlatt & Donovan, 2005; G. A. Marlatt & George, 1984).

On the other hand, an individual's behaviour is often impulsive and automatic (Sheeran, Gollwitzer, & Bargh, 2013). Creating relevant responses to particular cues can facilitate behaviour maintenance. Forming positive habits and unlearning negative ones can make behaviour change easier (Bas Verplanken & Faes, 1999). People are successful in maintaining behaviour if their psychological (Baumeister, 2003) and physical resources (Bartley, 2004) are plentiful. A supportive

environment (C. May & Finch, 2009) and social support (Edward L. Deci & Ryan, 2010) are associated with health behaviour maintenance. The key themes identified in the behaviour maintenance review were applied as a framework in the current study to explore sustained weight loss.

### **5.2.3 Qualitative studies of WLM**

Several qualitative studies have examined WLM experiences in people who have lost weight (for systematic reviews of qualitative WLM studies see: I. Brown & Gould, 2011; Garip & Yardley, 2011). A number of these studies compared weight regainers with weight maintainers and report differences between the two groups (Barnes et al., 2007; Byrne et al., 2003; Kayman et al., 1990; McKee, Ntoumanis, & Smith, 2013; Reyes et al., 2012). Common characteristics of weight loss maintainers included: being aware of their weight-related behaviour (Kayman et al., 1990); using personally developed coping strategies to overcome behavioural barriers (Barnes et al., 2007; Kayman et al., 1990; McKee et al., 2013); having exercise and eating routines (Kayman et al., 1990; McKee et al., 2013; Reyes et al., 2012); and using available social support (Barnes et al., 2007; Kayman et al., 1990).

In contrast, weight loss regainers were described in terms of: a lack of motivation (Reyes et al., 2012) or awareness with regard to weight control (Byrne et al., 2003; Kayman et al., 1990); failure to achieve weight goals and dissatisfaction with the weight achieved (Byrne et al., 2003); emotional eating (Byrne et al., 2003; Kayman et al., 1990); the tendency to evaluate self-worth in terms of weight and shape and a dichotomous (all-or-nothing) thinking style (Byrne et al., 2003). Regainers also

reported not having an exercise and eating routine (Kayman et al., 1990; McKee et al., 2013; Reyes et al., 2012), and not making use of available social support (Kayman et al., 1990).

One study reported overlapping characteristics of regainers and maintainers including a decrease in self-monitoring of food intake over time as new habits developed, experiences of lapses, using clothing fit for feedback on weight status, and desiring greater support during WLM (Reyes et al., 2012). Reported BCTs used by successful weight loss maintainers, but not frequently by regainers, were self-monitoring (McKee et al., 2013), problem solving (Kayman et al., 1990; Reyes et al., 2012), regular self-weighing, and using positive self-talk (Reyes et al., 2012). These are typical factors/characteristics of participants in studies; however, it is possible that, at an individual level, only some factors/characteristics are relevant. Whilst previous studies have assessed opinions on factors underlying successful and unsuccessful WLM, this is the first study to assess those opinions when presenting participants with real-time gathered data regarding individuals' personal experiences of WLM.

#### **5.2.4 Data-prompted interviews**

Various prompts have been used in previous qualitative weight management studies, including pictures (Keller, Fleury, Perez, Ainsworth, & Vaughan, 2008; Lachal et al., 2012), videos (Arterburn et al., 2011) and graphical representations (Sheridan & Chamberlain, 2011). Data used during an interview can be provided by the participant, but can also be gathered through EMA (Saul Shiffman et al., 2008;



Stone, Shiffman, & DeVries, 1999). EMA involves repeated measurement of participants in real-time, and in their natural environments (Saul Shiffman et al., 2008). Respondents are typically asked to answer questions, take pictures or write notes. In addition, the data presented to the participant can also be captured automatically, e.g. with accelerometry or GPS measures (Oliver et al., 2010). The use of data in an interview context has the potential to enhance participants' memory and to document individual change in assessed variables (Sheridan et al., 2011). The method of data-prompted interviews is described in detail in Chapter 4.

### **5.2.5 Longitudinal qualitative research**

Interviews which are repeated at more than one time-point with the same participants are often referred to as Longitudinal Qualitative Interviews (LQI) (Hermanowicz, 2013). Typically LQIs are used to study how people experience and respond to change. These types of interviews are also important means of assessing whether opinions, perceptions and cognitions remain stable within individuals. LQIs are suitable to explore complex processes such as WLM (Malpass, Andrews, & Turner, 2009), as they allow reflection on changes (or lack of change) that individuals have experienced since the first interview. There is no specific guidance on how many times participants should be assessed or how long the optimum time period should be between the interviews (Hermanowicz, 2013), as it mainly depends on the topic under investigation and on the time expected for changes to occur.

An example of weight-related LQI is a study involving type 2 diabetic patients assessing how perceptions and understanding of the condition changes over time (Lawton, Peel, Parry, & Douglas, 2008). Here, participants were assessed four times over the study period, and results showed that, whilst some opinions remained stable, others shifted and the experience of living with and managing diabetes over time were central to changes in opinions and beliefs.

### **5.2.6 The reported study**

The study presented here aimed to examine the WLM process in previously obese adults who had successfully lost clinically significant amounts of weight (5% and more) in the previous year. The study was informed by a systematic theory review exploring predictions for behaviour change maintenance (Chapter 2). Data-prompted, semi-structured interviews were undertaken with individuals who had lost significant amounts of weight and who took part in the WLM *N-of-1* study (Chapter 3). Various sources of data were used to evoke narratives and explore WLM, including quantitative data summaries, photographs and written narratives. The majority of participants were interviewed at two and then at six months after joining the study, to expand on the provided accounts and to assess if any changes in perceptions had occurred. The primary aim of the study was to explore theoretical explanations of behaviour change maintenance and to gain a deeper understanding of WLM using theoretical themes (Chapter 2). The secondary aim of the study was to explore benefits and challenges of employing DPI in WLM study were also explored.

## 5.3 Methods

### 5.3.1 Design

A longitudinal qualitative study involving two waves of semi-structured, in-depth interviews was carried out, prompted by data collected through EMA and experience sampling embedded within the *N-of-1* study (Chapter 3). Figure 7 provides a summary of the study timeline.

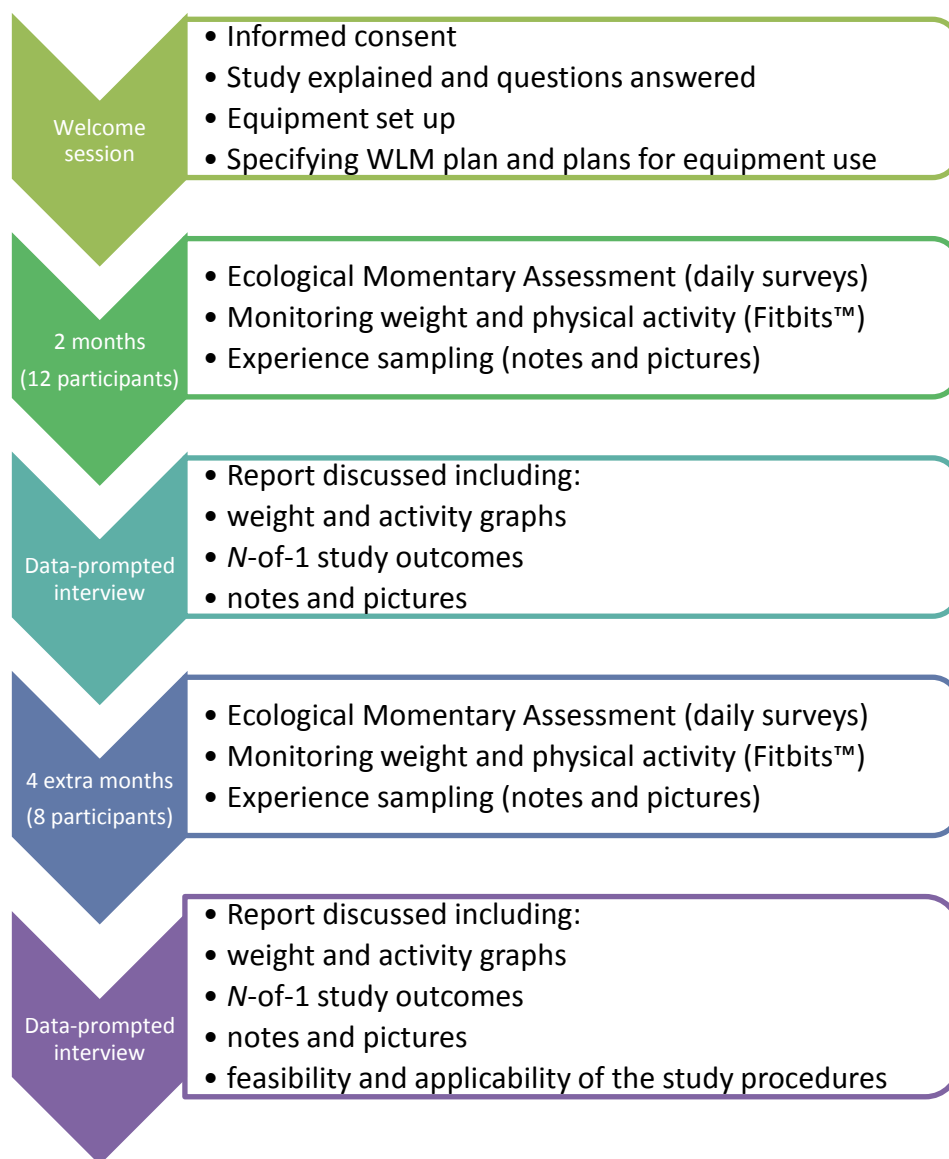


Figure 7: Weight loss maintenance study flowchart

### **5.3.2 Participants**

This study included participants who took part in the *N-of-1* study. For participant details and study inclusion/exclusion criteria see Chapter 3.

### **5.3.3 Study components and measures**

The study was divided into the following study components/activities:

#### **1. Proactive experience sampling**

Throughout the *N-of-1* study (Chapter 3), participants were asked to proactively collect ‘experience samples’: notes and pictures of anything that related to their WLM. Notes were participant-initiated (written and sent at any time) and researcher-initiated (each evening the EMA questionnaire included a notes/comments section). These individual experience samples were sent to a study e-mail address, which was separate for each participant. Participants decided on the frequency of collecting experience samples, and they were free to send any data that they considered relevant to their WLM.

#### **2. Data-prompted interviews**

Participants of the *N-of-1* study (Chapter 3) were interviewed after two months of study participation and if they decided to continue with the study, then they were interviewed again after four months (total study duration was maximum 6 months per participant). Before each interview, a report was prepared for each study participant. This report was based on the participant’s personal data including: weight and activity graphs; averages of each assessed predicting factor and

outcome; correlations of psychological factors with WLM plan adherence; and participant-generated and interviewer-segregated notes and pictures.

During the interview, each participant was presented with a personal report that guided the interview discussion (an example of a 2 month report is provided in Appendix F and a 6 month report in Appendix G). The interviewer also had a topic guide with some pre-defined questions (Appendix H). Following the initial two month period, participants were offered the option of continuing with the study. For the final follow-up interviews, participants were re-interviewed with a similar report covering six months of data while in the study. The same interview manual was used, with some additional questions regarding the feasibility and applicability of the study procedures (results reported elsewhere: Kwasnicka, Dombrowski, White, & Sniehotta, 2014).

#### **5.3.4 Procedure**

The study was embedded within the *N*-of-1 study described in Chapter 3. The study took place in Newcastle-upon-Tyne (UK) between August 2013 and March 2014. The research was approved by the Newcastle University Ethics Committee (REC 00648\_1). Participants attended an introductory meeting with a researcher, during which their eligibility was assessed and the study explained in detail. All participants provided written informed consent. For two months prior to the interview, participants gathered data regarding their WLM through ecological momentary assessment and experience sampling. Prior to each interview the aforementioned report was prepared for each participant. The interviews took place in Newcastle

University and lasted on average one hour each. All interviews were audio-recorded and transcribed verbatim.

### **5.3.5 Data analysis**

Transcripts were imported into NVivo 10 qualitative data analysis software (QRS International <http://www.qsrinternational.com/>) for data management and coding. As the interviews were data-prompted, participant-related data was stored and analysed together with the interview recordings (reports summarising outcomes, diagrams, photos and experience samples). The primary researcher (DK) undertook initial computer-assisted coding following the principles of Framework Analysis (Spencer et al., 2003); 15% of the data (transcripts and participant-provided data) were double-coded, with each line of transcript coded as a separate unit of data (SD). Framework analysis involved familiarisation with data, applying a thematic framework, charting, i.e. re-arranging data to appropriate parts of the thematic framework, mapping and interpretation. This allowed flexibility to generate new themes and to further inform the framework. The results are first summarised addressing specific objectives of the study and then presenting illustrative data.

## **5.4 Results**

### **5.4.1 Main findings**

Twelve participants took part at the two-month interview stage and eight took part in the six-month follow up. The number of experience samples generated varied between participants who, in total, gathered 155 pictures (range 0-91 per person; 5

participants did not send any pictures) and 1,153 notes (range 11-344 per person).

Table 10 shows the length of study participation, weight, and the number of experience samples generated per participant.

Table 10: Summary of participants' characteristics and number of experience samples gathered by each participant

P	Sex	Age in 2014	Weight at the start (kg)	Weight at 2 <sup>nd</sup> month (kg)	Weight at 6 <sup>th</sup> month (kg)	Number of pictures provided	Number of notes provided
1	F	56	94.79	95.48	95.97	0	144
2	F	56	76.73	73.85	71.61	9	137
3	F	50	86.23	84.18	81.41	36	112
4	F	45	63.54	65.05	60.45	91	344
5	M	32	89.46	88.74		0	52
6	M	50	129.75	121.37	124.53	6	95
7	F	37	82.46	80.60		1	14
8	M	61	86.11	84.90	77.79	1	27
9	F	62	83.96	83.84		0	41
10	F	50	96.64	96.04	101.01	0	41
11	F	64	72.70	76.01	73.47	11	135
12	F	44	67.00	69.74		0	11

*Note.* F – female, M – male; participants 5, 7, 9 and 12 participated in the study for 2 months.

The agreement between two independent coders (DK and SD) was checked, with Krippendorff's alpha reaching 0.89 for interview transcripts and 0.81 for participant-generated notes. Disagreements were discussed between the coders and consensus reached on all discussed data points.

The results of the study showed that there is a time specific variation in weight-related cognitions and outcomes. The same participants often displayed characteristics which were associated with successful and unsuccessful WLM, and changes in context, cognitions and outcomes were often temporary. Depending on the day, the same participant could be categorised as a successful or an unsuccessful weight loss maintainer. The ability to balance out the characteristics that determined unsuccessful WLM determined overall success.

There was a lack of pronounced change within participants' opinions and beliefs reported between the first and the second wave of interviews. New accounts emerged, including more variation in weight and activity patterns, and a broader range of examples of experiencing relapse. Overall opinions and beliefs regarding the main theory-driven themes remained stable.

The study showed that reported experiences of WLM were mainly in line with the theoretical explanations for behaviour change maintenance. New sub-themes emerged, including goal conflict and specific strategies within the self-regulation process. The main themes prompted in the narratives included maintenance motives, self-regulation, resources, habits and environmental and social influences. Themes are described separately below, with interrelated influences highlighted.



### 5.4.2 Maintenance motives

Participants discussed sustained motivation to maintaining weight loss, with an emphasis on internal over external motivation. Several internal motivators were named such as a desire to be healthy and fit as well as satisfaction with their new lower weight.

*“What motivates me is being healthy, being slim and living a long and healthy life, happy life [...] It’s like a promise I’ve made to myself that I’m not going to go back to what I was before.”* Participant 1, female, 56, 2 months.

Participants often emphasized the difficulty of sustaining motivation long term (Figure 8).

29<sup>th</sup> March 2014 21:36

***Went for a run<sup>7</sup>***: *“Felt great afterwards, but it's always a mental battle to motivate myself and get out there.”*

Participant 3, female 50, 6 months.



Figure 8: Experience sample - Internal motivation

<sup>7</sup> Picture titles provided by participants are written in bold for all included experience samples to differentiate them from the message content.

They also often referred to satisfaction with the outcomes of weight loss, for instance being able to wear smaller sized clothes and being more active.

*“You feel a lot nicer in yourself when you have lost the weight, you know I can start to wear gear that I really want to wear, like trendy boots and trendy clothes [...] And that’s what I want to do, I don’t want to feel as if I’m a frump, you know and that’s what I was feeling like before.”* Participant 2, female 56, 2 months.

Satisfaction with outcomes was reported to be crucial to sustaining motivation in order to maintain weight loss (Figure 9).

29<sup>th</sup> September 2013 19:13

***New boots:*** *“These boots are just fab and they fit me well which they didn't before I lost weight. The weight is definitely staying off this time!”*

Participant 2, female 56, 2 months.



Figure 9: Experience sample - Satisfaction with outcomes

Participants often referred to the enjoyment associated with maintaining weight loss. They mentioned activities that they introduced into their lives in order to

maintain weight that they now enjoy engaging in. For instance new sports activities, healthy cooking, or being able to get involved in activities that they were unable to do before they had lost weight (e.g. playing with grandchildren).

*“Yes, I never thought I would like walking. Obviously when I didn’t like walking it was because I was carrying all the extra weight. Whereas now I quite enjoy going out in the morning and having a walk around. [...] I quite enjoy that.”* Participant 11, female 64, 6 months.

Participants described engaging in activities and events which were enjoyable and which also allowed them to manage their weight. These pleasurable situations frequently included physical activity and healthy food preparation with family members or friends (Figure 10).

9<sup>th</sup> February 2014 16:13

***Getting the kids involved:***

*“Reduced fat cheese savoury with natural yoghurt and light mayo, having fun with my kids.”*

Participant 4, female 45, 6 months.



Figure 10: Experience sample - Enjoyment

Participants referred to an identity shift, often from being a constant dieter to accepting a new mindful way of life.

*“This is totally different [than being on a diet]; this is a change for life and a change for me. So that’s had quite a different way in how I view it. I don’t view myself as being on a diet. Because I’m not, this is what I’m going to do for the rest of my life.”* Participant 10, female 50, 2 months.

#### **5.4.3 Self-regulation and coping with behavioural barriers**

The second main theme that was examined in the narratives was active self-regulation and coping with behavioural barriers. Self-regulation and self-monitoring were recurrently referred to. The majority of participants talked about monitoring what they ate, how active they were, and how much they weighed.

*“I have realised I have to consciously self-regulate it [my weight], if I’m in my normal weight, and if I do what I want, then I will put on weight, I’ve realised over the last year or so and I certainly made a conscious effort to reduce my calorie intake. [...] I found when I stopped regulating as hard that’s when I started to put the weight on [...] but if I’m bothered about my weight and want to keep it down then I’m much more disciplined with myself and will restrict the calories intake each day.”* Participant 5, male 32, 2 months.

Experience samples sent by participants often included accounts of active self-regulation, describing conscious decisions they made in order to manage their weight (example presented in Figure 11).



29<sup>th</sup> December 2013

**Day out:** *“Chose Harvester restaurant, they have the calorie count on meals on the menu, chose alcohol free larger, 52kcal per bottle!”*

Participant 6, male 50, 2 months.

Figure 11: Experience sample - Self regulation

Self-regulation was often goal-directed, whereby participants set themselves an activity goal (e.g. number of steps per day, number of gym visits per week) or a healthy eating goal (e.g. number of calories per day, avoiding certain trigger foods). They often referred to their commitment to the goal that they set.

*“I know exactly when I should be eating, how much I should be eating, I know what I want to eat each day and I try and hit that target really.”*

Participant 5, male 32, 2 months.

Within the notes and pictures, participants often reported on self-monitoring weight and step count (Figure 12) and on setting and maintaining goals. Although participants aimed to avoid weight regain and maintain weight loss, a majority also wanted to lose additional weight.



8<sup>th</sup> April 2014 10:09

**Yay!!!:** *This is what I've been aiming for - my next milestone of getting under 12 stone! [...]*  
*So happy - I'm half way to my target weight!*

Participant 3, female 50, 6 months.

Figure 12: Experience sample - Goal-directed self-regulation

Lapses, relapses and coping with temptations were often described in terms of how the individual responded to a particular situation. Periods of more successful WLM were associated with participants consciously allowing for special occasions or sporadic treats; often compensating for them with increased amounts of physical activity or enhanced self-monitoring on other days. During less successful WLM periods, participants referred to special occasions and treats in terms of failure, disappointment and feelings of guilt; often justifying instances of lapse or relapse by referring to external factors (e.g. time pressure, tiredness or social influences).

*“What I have learned to do, is like in the past when I’ve been on weight maintenance programmes or diets or whatever you want to call them. When you are sort of, falling off the wagon, you stay off. Now I’ve got into a routine that I can have an odd like but the next day you’ve got to get back on track, to the Weetabix in the morning and stuff like that and I’ve got that mind-set that I can actually do that.”* Participant 6, male 50, 2 months.

Establishing a non-food reward system supported weight management. Participants often identified incentives that they used to reward themselves for maintaining weight and for following WLM plan (Figure 13).

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	<p>17 January 2014 20:22</p> <p><b><i>New top!</i></b>: <i>“This is my reward for keeping the weight off this week. Better than buying chocolate!”</i></p> <p>From the interview: <i>“Yes, it is nice to be able to buy clothes now. Whereas before when I was really big there wasn’t the choice and I didn’t have any interest. My wardrobe consisted of a black skirt, a black top and that was basically it. Whereas now it is nice to be able to go out and buy different things.”</i></p> <p>Participant 11, female 64, 6 months.</p>
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Figure 13: Experience sample - Successful coping with barriers

Relapse was often associated with going off track and allowing short-term indulgence as a response to internal or environmental factors (Figure 14).



26<sup>th</sup> October 2013 18:46

**Bad day:** *“Good job I don't do this very often”*

From the interview: *“I had those, like I say, in as a present so I went to the cupboard and got those. He [husband] brought me those back and I thought, well I'm just going to sit and eat them all. So I did... ”*

Participant 2, female 56, 6 months.

Figure 14: Experience sample - Unsuccessful coping with barriers

Some participants, especially at the six-month interviews, referred to experiences of internal goal conflict, where other events or influences occasionally disrupted their effective weight regulation.

*“Like I said, the redundancy threat and working through that was my main goal, and main priority. [...]. You start thinking a lot deeper and deeper, like, ‘How am I going to pay mortgages?’ and stuff like that; ‘support my family?’. There're a lot of issues there that you've got to deal with, and those, obviously, took priority over my weight maintenance plan, as such, because that's just the way.”* Participant 6, male 50, 6 months.

#### 5.4.4 Psychological resources

Participants often referred to cognitive boundary conditions (i.e. limited psychological resources) that prevented them from successfully maintaining their



weight loss. The most frequently mentioned factors were stress, boredom, tiredness and perceived lack of time.

*“If I'm stressed or very busy, sometimes it's easier to get the quickest thing to eat, which isn't always the healthiest. And I think I've slipped a bit in sort of making sure I prepare meals with a lot of vegetables in, which I had been doing. But just because I've been so busy and sort of rushed, and not had a lot of time to prepare.”* Participant 3, female 50, 6 months.

Experience samples often illustrated situations that impacted on weight management such as traffic jams, stressful meetings, and house redecorations (Figure 15). In these circumstances, participants were more likely to report being anxious and WLM was more difficult to focus on.

	<p>2<sup>nd</sup> December 2013 19:53</p> <p><b><i>Extra aches and pains!</i></b> <i>But worth it - our floor is starting to take shape - under-floor heating on its way. Cannot imagine feeling warm again after several weeks of stress and being freezing cold.</i></p> <p>Participant 11, female 64, 2 months.</p>
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Figure 15: Experience sample - Resources

Some participants also mentioned the impact of health problems and other competing issues that were prioritised over WLM. There was a clear emotional response to successful weight management in most participants. For example,

participants talked about feeling pleased when they were able to follow their WLM plan but reported various negative feelings associated with not following the plan, such as disappointment, frustration and anger. Experiencing negative emotions and extreme self-regulation was reported as often leading to binge eating and relapse.

#### **5.4.5 Habit and automaticity**

The majority of participants reported relying on automatic and cue dependent behaviour when their psychological resources were limited. Many referred to coming back to negative habits they had prior to their weight loss when they were emotional, tired, stressed, or when they had other competing goals (e.g. getting home faster, being able to relax earlier). Negative habits in terms of unhealthy food choices and a sedentary lifestyle often hindered WLM goals.

*“I went round, somebody had been for Sunday lunch, [...] somebody had brought some chocolates so I took them out and opened the tin and presented the tin to him [her husband], all these lovely chocolates, and he said ‘where have they all gone?’ There was only half of the thing left you know; I said ‘I think I must have eaten them!’. You know so it’s almost as if I’m doing it and I’m not absolutely particularly aware of doing it. [...] I’m defeated in the evening when I’m tired, stressed.”* Participant 9, female 62, 2 months.

Participants often referred to their negative habits during the interviews but only a limited number of these habitual situations were captured within experience samples. This was expected as habits are unconscious responses to contextual or situational cues. Figure 16 shows how habits related to environmental cues, and

how cue-behaviour associations were activated when specific situational patterns were encountered.



31<sup>st</sup> December 2013 17:16

**No title:** *Only fast food vans open at lunch time New Year's Eve.*

From the interview: *This is just all the vending huts there was like, you can get hot dogs there, baked potatoes there, pizza there and it's just the line-up, and the smell is just gorgeous and that's the sort of temptatory stuff.*

Participant 6, male 50, 6 months.

Figure 16: Experience sample - Negative habit

In contrast, participants also reported that they had developed various habits which supported their WLM. In terms of healthy eating, they often referred to regular healthy meals (Figure 17), reading food labels, automatically shopping for healthy foods, and choosing healthier and lower calorie options from the menu. In terms of physical activity, participants referred to being active as a part of their routine, using active transport such as walking and cycling, automatically choosing stairs over escalators, and building regular exercise into their daily routine.



22<sup>nd</sup> October 2013 12:43

**Lunch:** *That's my lunch every day when I am at work.*

From the interview: *That's my lunch, that's my lunch every day when I am here virtually, virtually although the other week I forgot my Philadelphia so I ended up eating a pasty (laughs).*

Participant 7, female 37, 2 months.

Figure 17: Experience sample - Positive habits

*"The more you do it, the more it's easier and it becomes a habit and you not consciously thinking 'oh I've got to have something low fat tomorrow' and it is becoming much easier now."* Participant 2, female 56, 2 months.

Participants often referred to WLM behaviours that they did automatically or without having to consciously remember.

#### 5.4.6 Environmental and social influences

Participants frequently referred to environmental influences, describing the negative impact of their surroundings which are often designed in a way that unhealthy food options are widely available and sedentary behaviours are dominant. Various attempts to restructure the environment in order to support WLM were described including changes in how people cook, where they eat, or what food they store at home. Participants often reported that eating healthily and

being physically active is more likely in their usual environment in comparison to when they are away, e.g. travelling (Figure 18) or visiting family members. Limited availability of healthy food options and possibilities to exercise was associated with reported difficulties to maintain weight loss.

*“I think, it’s difficult when you are taken out of your environment because you don’t have any control over what you are given [to eat] so for example, if I go to my wife’s parents for tea I don’t choose what I am going to have for tea, I don’t have the option to suddenly go off and say ‘see you guys I’m off to the gym’. You don’t have that much flexibility that you have when you are at home, when I am in control of what we have for dinner every time, I’m in control of if I can go and exercise.”* Participant 5, male 32, 2 months.



3<sup>rd</sup> April 2014 21:00

***Temptation:*** *“How do I choose fruit when this is on offer???”*

*From the interview: “Every break they had stuff like that. Loads of food in the evening as well, and plus it’s a different environment, you have to try different things. So I didn’t resist those as much maybe as I should have done...”*

Participant 3, female 50, 6 months.

Figure 18: Experience sample – Environment

Social influences had both a positive and negative impact on WLM. Positive impacts included the creation of support systems to help the individual maintain weight loss and additional motivation to stay healthy and to maintain new lower weight.

*“My family are a hundred percent behind me; at work my colleagues are all very supportive as well.”* Participant 6, male 50, 2 months.

**Note:** *Observations of a would be thin person: I always tell myself, “remember WHY you are doing it!”* P4, female 45, 6 months. (Picture of her children attached with a note; excluded for anonymity considerations).

However, negative impacts were also mentioned including social pressure on the individual to comply with social norms, e.g. to drink alcohol, or to eat calorie dense foods (Figure 19).

*“We eat when we are sad, we eat when we are happy, we eat to celebrate and to mark an occasion. You can’t seem to escape it, can you? If you try to say, ‘No’ you almost feel as if you are being antisocial or you are insulting the hostess because they have prepared this food and you feel you should eat it. It is difficult making people realise that you can still have a nice time, you can still go out and have fun but you don’t necessarily need to be eating and drinking all of the time.”* Participant 11, female 64, 6 months.



14<sup>th</sup> January 2014 13:10

**Banoffee pie:** *“My colleague bought a slice for me I did refuse it!”*

Participant 6, male 50, 2 months.

Figure 19: Experience sample - Negative social influences

There was a discrepancy between participants in terms of how much social support they perceived as necessary, varying from no need for social support in WLM to frequent, almost daily support perceived to be necessary.

#### 5.4.7 Benefits and challenges of employing DPI in WLM study

There were various benefits of using the DPI method to investigate WLM experiences in people who lost weight. DPI extended beyond the conversation as other senses came into play, e.g. emotions associated with presented stimuli were often expressed during the interview.

[Participant and researcher look together at the picture] Participant: *“God when I look at that one, I just think how horrendous do I look? I mean, I do just look absolutely terrible, I look fat. Mind, those tights don't look good either [...] I just feel so uncomfortable there [...] and that's what encourages me to keep going and to maintain my weight.”* Participant 2, female 56, 2 months. (The relevant picture excluded for anonymity considerations).

Data presented to participants often stimulated their memory, allowing them to overcome memory bias. Moments of lower self-control were often included in notes, pictures and they were also apparent on the weight, activity and plan adherence time-plots (Figure 20).

Researcher: *“Do you remember any situations when you came across some barriers to maintain your weight?”* Participant: *“Not recently, no [researcher puts out picture taken by the participant titled ‘cake at the work meetings’] oh, yes, I think it’s horrible, I think people should be more thoughtful, because I’m sure I can’t be the only person in the world that has got to watch what they eat [...] you don’t really want it or you are trying very hard not to have it and if they weren’t there I wouldn’t even think about them.”*  
Participant 4, female 45, 2 months.



**Note:** *“Team meetings really seem to involve cake too often. Hard to resist for an hour and a half when trying hard to stay engaged... must be strong...”*  
Participant 4, female 45, 2 months.

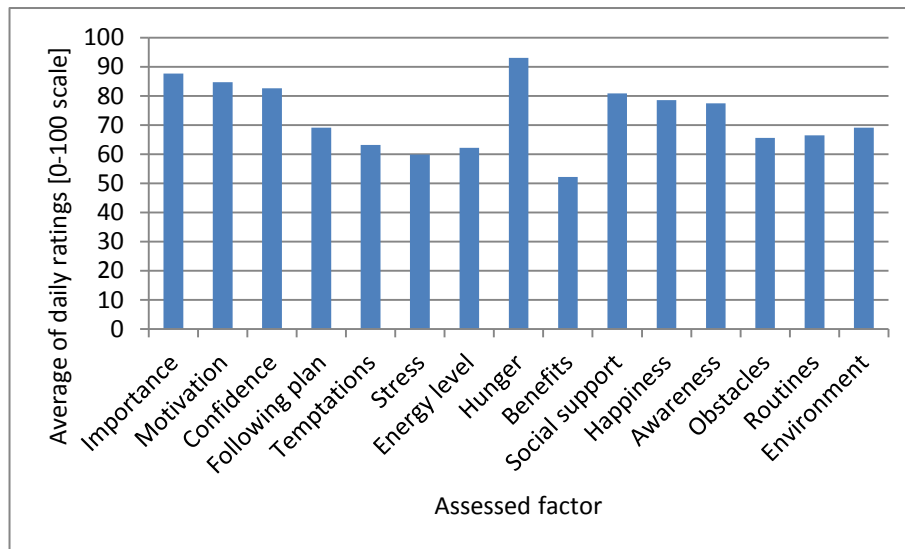
Figure 20: Benefits of DPI – stimulating memory

From the researcher perspective, the interviews allowed clarification (Figure 21) and explanation of data patterns (Figure 22).



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[Participant and researcher look together at average daily ratings of hunger]



Researcher: *“So, first, starting from hunger, on a daily basis you seem to always rate your hunger really high, and I was wondering if you could think what can cause this?”*

Participant: *“Oh, I think I’ve answered that the wrong way round coz I never feel hungry.”*

Researcher: *“Oh really?”*

Participant: *“Yes, I think that’s my fault (both laugh), sorry”*

Researcher: *“Oh so that should be the opposite...”*

Participant: *“Yes, that should be the opposite, I very rarely feel hungry.”*

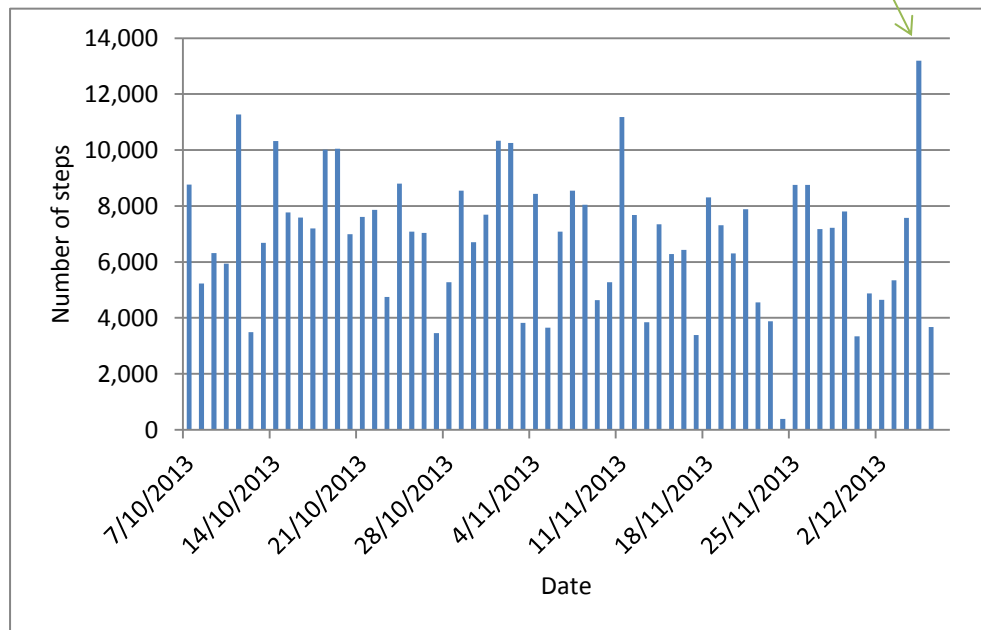
Researcher: *“That’s really good to know. Right I’ll note this down and take it into account while further analysing your results.”* Participant 1, female 56, 2 months.

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Figure 21: Benefits of DPI – for the researcher (a) clarification of the data

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Participant: *"I love that, see that day there? [points to the data point on the diagram showing number of steps per day]"*



Researcher: *"Yes, what happened?"*

Participant: *"Christmas shopping with my mum and I took it off [points to the activity monitor] and I was like 'oh my goodness, I need to shop more!' (Laughs), I did about thirteen thousand steps just from shopping, I thought it was great, shopping is good for you!"* Participant 7, female 37, 2 months.

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Figure 22: Benefits of DPI – for the researcher (b) explanation of the data

For the participant the report provided topic and guidance for discussion, i.e. something to find out about themselves.

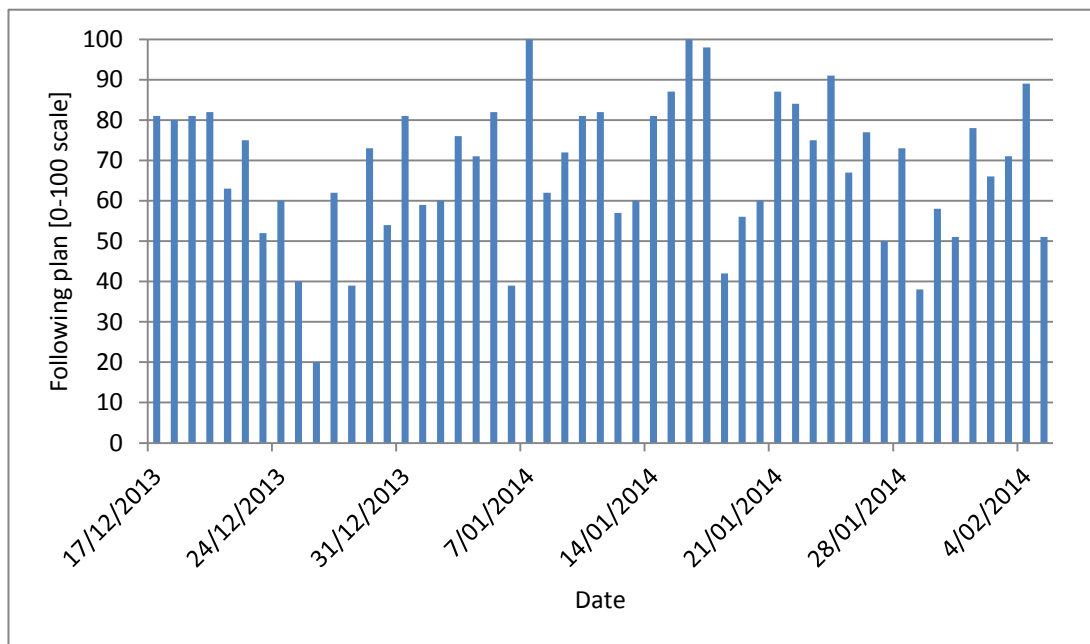
[Participant presented with averages for how many steps she walks per day (weekday versus weekend day)] Participant: *"That was the interesting thing about it because I think before I did this [the study] I think when I use to wear my own pedometer on some days I was only getting about 2,500 steps in and so this one actually pushed me, for all I haven't got up to the 10,000 which was more than what I should be doing, it definitely did push me to do*

*that little bit more, thinking about how I could get them in, so yes, and that was really interesting.” Participant 11, female 64, 6 months interview.*

There were also challenges of using DPIs to investigate WLM experiences in people who recently lost weight, including practical, analytical and ethical challenges. Data needed to be carefully selected for the interview report and clearly explained to the participant (Figure 23).

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Researcher: *“On this page we can see your ratings for your plan adherence, so basically each of the blue lines represents one day so on the days when you mark them lower, here you can see [researcher points to the data point on the graph], then you are less likely to follow your plan. We can see how the blue lines varied in the last two months.”*



Graph for participant 4, female 37, 2 months.

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Figure 23: Challenges of DPI – need to clarify and simplify the data

Several images of family members, including children were provided as experience samples but they could not be used and included in analysis due to the lack of consent. At times data analysis proved challenging due to lack of video recording.

Participant: *“And here you see it wasn’t a good day at all [participant points to a point on the graph showing step count]. And this one was much better [participant points to another point on the same graph]. Overall I was very motivated but then I came across this [participant points to a picture showing food vendors selling fast foods]. So again I couldn’t resist so that’s why here I couldn’t put anything above 50 [participant points to a graph showing daily ratings for WLM plan adherence]”* Participant 6, male 50, 6 months.

## **5.5 Discussion**

### **5.5.1 Main findings**

Using personal data prompts created unique features of the interviews. Data presented to participants evoked memories and stimulated informed discussion. Through the process of gathering person-specific daily data prior the interview, the interviewer built rapport with study participants. Participants expressed their views regarding WLM but were likely to alter them when they contrasted with their own data, e.g. when shown which predictive factors showed the strongest correlation with outcome (WLM plan adherence).

The outcomes suggest that successful WLM is time-specific and people who succeed over the long term often share the characteristics of weight-regainers that have been identified elsewhere (Barnes et al., 2007; Byrne et al., 2003; Kayman et

al., 1990; Reyes et al., 2012). What distinguishes those individuals with successful long-term WLM is their ability to balance out the characteristics associated with unsuccessful WLM to accommodate a new healthy lifestyle. This suggests that the distinction of the characteristics between weight loss maintainers and weight loss regainers may be temporary and less pronounced than that reported in previous studies (Barnes et al., 2007; Byrne et al., 2003; Kayman et al., 1990; Reyes et al., 2012).

In participants interviewed twice there was more variation in weight and activity patterns, and a broader range of examples of relapse. However, their opinions and beliefs regarding the main themes were maintained. Since this study assessed how people *maintain* new lower weight, substantial changes in opinions and beliefs within participants who were assessed in the LQI were not expected. In other qualitative studies that examine before and after initial weight loss experiences (Herriot, Thomas, Hart, Warren, & Truby, 2008) or assess coping with a condition which prompts people to engage in weight loss activities (Lawton et al., 2008), changes in cognitions were reported. In our study, during the second wave of the interviews new, more detailed accounts were provided that reinforced previously gathered narratives. The results suggest that the LQI may be more valuable to explore weight loss than WLM.

The applied theory-informed framework developed through the theory review described in Chapter 2 provided a good fit for the narratives which emerged from the interviews, and new sub-themes were identified. Results of this study were

mostly in line with the framework and with previously reported outcomes of studies investigating WLM and maintenance of health-related behaviour. The detailed results are discussed below in relation to prior knowledge of the five theoretical themes derived from the theory review (Chapter 2).

## **5.5.2 Relationship to existing knowledge**

### **5.5.2.1 Maintenance motives**

The findings presented here suggest that one of the factors that allows people to maintain weight loss is maintained motivation. This is in line with existing empirical evidence showing that sustained motivation is crucial for the maintenance of health-related behaviours such as physical activity (van Stralen et al., 2009), alcohol abstinence (Adamson, Sellman, & Frampton, 2009) and abstinence from smoking (Vangeli, Stapleton, Smit, Borland, & West, 2011). In line with Self-Determination Theory (Edward L. Deci & Ryan, 2010), sustained intrinsic motivation as well as extrinsic motivation are necessary in order to maintain behaviour.

Participants in this study emphasised the importance of satisfaction with WLM outcomes in maintaining their new lower weight. In line with our findings, other studies of WLM also showed that the more satisfied a person is with behaviour change outcomes, the more likely they will be to continue to perform behaviours associated with WLM (Finch et al., 2005; Kristal et al., 1992). These findings were also in line with WLM theory (A. J. Rothman et al., 2009), suggesting that a key determinant for reflective behaviour maintenance is satisfaction with behaviour change.

An important motivator was the enjoyment of activities that allow people to maintain their weight loss. Results presented here echo findings of previous research investigating WLM which shows that in order to maintain activity people have to take pleasure from it (Kruger, Blanck, & Gillespie, 2006; Poobalan, Aucott, Precious, Crombie, & Smith, 2010). In line with Regulatory Fit Theory (E. Tory Higgins, 2005), an absence of enjoyment is theorised as a main reason for disengagement from the behaviour. In contrast to our findings, another study assessing whether WLM becomes easier over time, showed that the pleasure derived from exercise, low-fat eating, and maintaining weight was unrelated to the duration of WLM (Klem, Wing, Lang, McGuire, & Hill, 2000). That is, there was no relationship between the enjoyment of WLM activities and how long people were able to maintain weight loss. The ability to find enjoyment in activities associated with WLM facilitated sustained weight loss; therefore long-term interaction effects should be further investigated.

For WLM the main identity shift occurred when an individual realised that they were no longer on a diet, and they accepted and adopted a new healthy lifestyle. The narratives presented in this study included an identity shift from a previously restrained individual towards a more liberated person in terms of dietary habits, emotional eating, physical activities, and social interactions (similar to that reported in: Epiphaniou & Ogden, 2010). The results were in line with predictions explained in the Process of Reinvention Theory (Ogden & Hills, 2008). Although this theory suggests that a significant event needs to take place in order for individuals to re-

invent themselves (to change identity), in the described study a significant event was not generally reported (unless the initial substantial weight loss is considered as 'an event'), whereas sustained changes in weight had a large impact on self-perceptions.

#### ***5.5.2.2 Self-regulation and coping with behavioural barriers***

Self-regulation and monitoring were often referred to in participants' accounts. In parallel to these findings, numerous studies have shown that monitoring food intake, physical activity and self-weighing facilitate WLM (Burke et al., 2011; Butryn, Phelan, Hill, & Wing, 2007). These results are also in accordance with Temporal Self-Regulation Theory (P.A. Hall & Fong, 2007), where people have different levels of ability to self-control their actions, called self-regulatory capacity. During the maintenance of behaviour, self-regulatory capacity determines how well intentions translate into actions. Presented findings have shown that in the context of WLM, how well a person is able to maintain weight loss is often determined by how well they are able to monitor and regulate their WLM-related behaviours.

In this study participants often reported having a WLM-related goal that they regulated towards and wanted to maintain. They mainly referred to three types of goal: activity, food and weight goals, setting themselves aims for how active they were, how well they ate and what weight they wanted to maintain or achieve. In line with Goal Setting Theory (Locke & Latham, 2002), sustained commitment to the goal directly relates to behaviour maintenance, especially when goals require



effort. This study found that participants' ability to meet those WLM goals was variable and it changed over time.

Participants were often dissatisfied with their ability to meet their WLM-relevant goals but still strived towards the overall goal to maintain their weight loss. Similarly in Gorin et al. (2007)'s WLM study, failure to meet weight loss expectations did not impact on maintenance in successful weight losers (Gorin et al., 2007). Even among successful weight losers, weight expectations were often not met and substantial further weight losses were desired; however these factors were not related to subsequent WLM outcomes.

In this study, participants often set themselves high activity goals to work towards. A similar study of increased physical activity recommendations showed that prescribing higher physical activity goals improved the outcome (Jeffery, Wing, Sherwood, & Tate, 2003). These results can be explained in light of Social Learning Theory, in that challenging goals may result in better overall performance because they allow people to attribute low progress or failure to meet the goal to the difficulty of the goal itself (Albert Bandura & McClelland, 1977). Failure to meet less challenging goals may be detrimental to the person as it may result in the decrease of self-efficacy and subsequent disengagement from the goal.

Coping with barriers and obstacles was often described in terms of proactive or reactive responses to a situation. More successful WLM was usually associated with planning for specific situations, allowing for treats and special occasions to occur. Less successful WLM was often associated with allowing for uncontrolled relapse.

These findings are in line with studies showing that planning for difficult situations allows an individual to overcome them more effectively (Kwasnicka, Penseu, White, & Sniehotta, 2013; Sniehotta et al., 2005).

Presented findings also suggest that 'occasional failure' to overcome behavioural barriers can be accepted and compensated. Individuals who are prepared for occasional failure are more likely to maintain behaviour in the long term. They often factor it into their plans, and are more flexible with themselves if something unplanned occurs. Accepting temporal circumstances and allowing for special occasions as a rare occurrence may facilitate WLM. This is in line with the Goal Conflict Model (Stroebe et al., 2008). According to this model, people who actively restrain from eating are more likely to engage in eating than people who are not actively regulating. There is a hypothesised goal conflict between eating enjoyment and maintaining weight, and that is why people who diet are more likely to overeat than people who are not dieting (Stroebe et al., 2008). Expanding on this theory, it can be suggested that people who allow themselves to occasionally eat unhealthily or be inactive are overall more likely to be successful in maintaining weight loss than people who constantly control their behaviour.

### ***5.5.2.3 Psychological resources***

All participants reported having temporary difficulties in maintaining weight when their cognitive resources were limited (e.g. when they were tired, bored, stressed, emotional, or under the influence of alcohol). Although participants often overestimated the role of certain cognitions on their behaviour, e.g. the impact of

stress on their WLM plan adherence, they were likely to alter their opinions when presented with quantitative data. In line with our findings, other studies have reported that difficulties in maintaining weight loss were often associated with high levels of stress (Sarlio-Lähteenkorva, Rissanen, & Kaprio, 2000), tiredness (Beccuti & Pannain, 2011) and perceived lack of time (Gaesser, 2013).

In line with Dietary Restrain Theory, dieters are vulnerable to uncontrolled eating when cognitive processes are disrupted, e.g. when people are distressed, intoxicated because they disinhibit inhibited or restrained eating (Herman & Polivy, 2004). Similarly our results can be also explained in light of the Strength Model of Self-Control (Baumeister, 2003; Baumeister et al., 1994) which suggests that when cognitive resources are limited, people are prone to engage in impulsive or automatic behaviours which often reflect habitual behaviour from before people had made initial changes, in this case before they had lost weight. Limits in cognitive resources played a role in WLM and were usually mediated by planning and other self-regulatory strategies. Through the process of repeating and embedding positive WLM behaviours, participants often learnt to deal with situations when such resources were limited.

Our study participants reported facing goal conflict when other competing demands took priority over WLM. An example of a major competing demand was a redundancy threat faced by one of the participants. This event, and its associated consequences, meant that the participant could no longer focus on WLM. Examples of other minor competing demands were daily events and their consequences, for

example being stressed, tired, emotional and wanting to relax with an alcoholic drink. At times when participants reported dealing with other demands, WLM was often less important and activities which required active self-regulation were discontinued. Explanations for how people pursue multiple goals via numerous behaviours are included in recent studies assessing behaviours of health care professionals (Presseau, Sniehotta, Francis, & Campbell, 2009; Presseau, Sniehotta, Francis, & Little, 2008), showing that other goals have a facilitating and interfering influence on the performance of behaviours. Future studies should explore how people prioritise WLM when their cognitive resources are limited, and when they are pursuing multiple goals.

#### **5.5.2.4 *Habit and automaticity***

In this study, behavioural WLM patterns were often based on cue-driven context-behaviour associations which were learned during the weight loss period and subsequently maintained. Numerous studies point to the adoption of an activity habit (Pronk & Wing, 1994), healthy eating habit (Shick et al., 1998) and self-weighing habit (Butryn et al., 2007) as key components in successful WLM. A systematic review of the Self-Report Habit Index applied to WLM-relevant behaviours showed that, in 23 habit-behaviour correlations of healthy-eating and physical activity behaviours, effects were medium-to-strong (Gardner, de Bruijn, & Lally, 2011). This suggests that habitual behaviours are easier to pursue as they require less executive control capacity than self-controlled behaviours.

Similar to our findings, in a conceptual review of factors associated with WLM and weight regain, having a physically active lifestyle, a regular meal pattern and healthier eating was associated with successful WLM (Elfhag & Rössner, 2005). Our findings can be explained in the context of other studies which report that individuals who had maintained weight losses for longer reported that less effort and attention was required to maintain their weight (Klem et al., 2000). This suggests that when habits develop, behaviours are easier to maintain as opposed to the behaviours that require active and reflective self-control. In line with Habit Theory (Bas Verplanken & Faes, 1999), behaviours performed automatically and without conscious thought and involvement require a minimal amount of cognitive processing. Thus activities which become habitual are easier to maintain, as they remain a default response when cognitive resources are limited due to stress, emotional dysregulation, or tiredness. Our study has shown that habit development and maintenance are essential for the WLM process.

#### ***5.5.2.5 Environmental and social influences***

In this study, participants reported that many of their WLM-related activities were elicited automatically when relevant contexts were encountered. Participants reported restructuring their environment in order to make it more WLM-friendly and their supportive environment has been shown to enhance WLM. Similarly, the impact of the environment on physical activity initiation and maintenance has been reported in various reviews of studies (Horne & Tierney, 2012; Thorpe, Johnston, & Kumar, 2012; van Stralen et al., 2009). Our findings were also in line with previous

studies assessing context discontinuity, which suggest that when environmental factors change a window of opportunity opens and allows for behaviour change and facilitates behaviour maintenance (B. Verplanken et al., 2008).

Participants often reported that avoiding obesogenic environments supported their WLM. This result is consistent with other studies (Lake & Townshend, 2006) and theoretical frameworks (ANGELO - Analysis Grid for Environments Linked to Obesity: B. Swinburn, Egger, & Raza, 1999). The environment influences the opportunities and choices individuals make in order to maintain their weight. Shaping the environment to better support WLM has the potential to be a key aspect of successful weight gain prevention.

This study showed that social support is a crucial part of the environment that impacts on WLM. The results showed that the need for social support was person-specific and variable. In line with our study, findings of other systematic reviews have also emphasized the importance of social support in the initiation and maintenance of health behaviours (Morris, Oliver, Kroll, & MacGillivray, 2011; Park & Gaffey, 2007; van Stralen et al., 2009). However, in contrast to previous findings that both successful and unsuccessful weight loss maintainers expressed a desire for greater support during WLM (Reyes et al., 2012), this study showed that some individuals (particularly men) reported that they did not need social support in order to maintain weight loss. This finding is also in line with previous literature on gender differences in perceived need for social support (van Dam et al., 2005).

In this study, participants reported positive but also negative social influences. They often referred to social norms which hinder successful WLM and emphasized overeating, drinking alcohol and being sedentary. Social persuasion was often directed against the needs and desires of the individual who wanted to maintain weight loss. This finding is in line with other reports on persuasion (Dillard & Pfau, 2002) and is closely in line with Social Norms Theory (Berkowitz, 2003). Other WLM studies have shown similar results. For instance, diet-related spousal support was associated with increases in patients' adherence to diabetic treatment; whereas diet-related persuasion and pressure were associated with decreases in adherence (Stephens et al., 2013). Understanding the environment of interpersonal influences is crucial in order to change and maintain behaviour. A person who strives to maintain weight loss has usually adopted effective strategies to deal with social influences, explaining their beliefs and motives, and often rejecting socially-accepted options in order to maintain weight.

### **5.5.3 Study strengths**

This is the first study to explore experiences of the WLM prompted by participants' self-gathered daily data. Key strengths are the theoretical framework, methods and outcomes. This study employed a robust theoretical framework, based on rigorous systematic assessment of a large number of theoretical explanations for behaviour change maintenance (Chapter 2). The method of data analysis allowed for framework flexibility and adding new themes as they emerged. Thus, new accounts have been added to expand and improve the framework. Participants' narratives

included predictions and explanations of behaviour maintenance that had not been included in the theoretical accounts. Expanding and reshaping theories of behaviour change based on empirical assessment is encouraged to inform redevelopment of useful and applicable theories (Sniehotta, Presseau, & Araújo-Soares, 2014).

This study used novel methods and the most recent technology to assess participants' experiences of WLM. To date, this is the first study which combines EMA (Carels et al., 2004; Saul Shiffman et al., 2008; Stone et al., 1999) with proactive experience sampling (Csikszentmihalyi & Larson, 1987; Hektner, Schmidt, & Csikszentmihalyi, 2007), wireless real-time activity and weight monitoring to provoke narratives regarding WLM. EMA has been used previously in WLM studies with paper-and-pencil diaries (Carels et al., 2004), while experience sampling has been employed in studies assessing real-time peer-interactions and physical activity (Salvy et al., 2008) and remote person monitoring has also been used in health-related studies (Dobkin & Dorsch, 2011). However, this study employed a unique combination of methods to gather person-specific data to inform the interviews and to avoid recall bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Bringing new data in the form of participant generated notes, pictures and graphs stimulated the interview discussion, clarified data patterns and evoked new narratives.

The study findings presented here contribute to the cumulative science of behaviour change maintenance. Reported outcomes were mostly in line with



previous theorising and outcomes of earlier studies; however some narratives contrasted with previous literature. Discrepancies were reported involving goal conflict, social influences, and various strategies used to self-regulate and deal with relapse. This study has shown that differences between successful and unsuccessful weight loss maintainers were time-specific and less pronounced than those reported in previous qualitative studies (Barnes et al., 2007; Byrne et al., 2003; Kayman et al., 1990; Reyes et al., 2012). The unique design employed in this study provided participants with the opportunity to contrast their beliefs and opinions with their own WLM-relevant data captured in real-time. The longitudinal element of the study allowed the assessment of whether perceptions reported at the first wave of the interviews were maintained and also included in the second wave of the interviews. Additional information was gathered at the second meeting, e.g. there were more opportunities to capture examples of lapse and relapse. However, most WLM explanations remained stable.

#### **5.5.4 Study limitations**

Study limitations included technical challenges, generalisability of the study findings and analytical challenges. Technical challenges involved an abundance of study data that had to be summarised for each participant prior to the interview. Some data had to be simplified, condensed or omitted to produce a report that could be feasibly explained to and discussed with study participants. Decisions made by the researcher when preparing the report could potentially influence and alter study

results. To keep participants focused on the presented data and engaged in the conversation, interviews were limited in time.

Other limitations included generalisability of the study findings, as the sample assessed was highly motivated to maintain weight loss. The outcomes could potentially vary among less motivated individuals (Williams, Grow, Freedman, Ryan, & Deci, 1996). Other components of the study, such as daily answering of WLM-related questionnaires, may have influenced participant behaviours and perceptions. Despite the fact that this study was designed to be purely observational, it included several BCTs (e.g. self-monitoring). The use of intervention techniques may have impacted on study results. Participants' environments and individuals around them had an impact on the WLM experiences; thus interviewing individuals in close proximity to the participants would allow corroborating the study outcomes.

There were analytical challenges in combining multiple and different data sources for the interview; interview transcripts had to be analysed closely together with reports and other data sources. A lack of video recording instigated some challenges with data analysis. Participants often pointed to specific data points when they were describing their behaviour, therefore some of the subtle detail of the narratives could be lost in the transcription process.

### **5.5.5 Study implications for WLM**

This study highlights five main areas and goals that policymakers and practitioners could concentrate on:

1. Enhancing people's motivation and providing incentives for WLM; moving away from diets and dieting towards healthy living and long term lifestyle change;
2. Supporting people in self-regulation, through the latest available technologies (Khaylis et al., 2010) which allow for weight, food and activity monitoring; emphasizing that infrequent lapses help to sustain weight;
3. Providing interventions that help people deal with temptations and obstacles when their psychological resources are limited, for instance through use of social media (Pagoto, Turner-McGrievy, Evans, Sepah, & Nilson, 2014) so that people can receive support provided in real-time;
4. Helping people maintain WLM habits by incentivising active transport, healthy food choices and by providing regular physical activity opportunities;
5. Reshaping the environment so that WLM is more feasible even when people are outside their normal environments, e.g. ensuring availability of healthy food options and options for being physically active; providing social support for people to maintain weight loss if they perceive that the support is needed. Overall, shaping the environment in a way that it is less obesogenic,

and through choice architecture nudging individuals towards healthy options (Thaler & Sunstein, 2008).

### **5.5.6 Unanswered questions and future research**

Future research should further progress behaviour change maintenance theory, expand on DPI research methods and further investigate presented WLM outcomes. This study has shown that multiple theoretical constructs can be used to explain WLM. There are frequent attempts to summarise and simplify theories that explain behaviour change (R. Davis, Campbell, Hildon, Hobbs, & Michie, 2014) and behaviour maintenance (Chapter 2). Summarising theoretical predictions for behaviour initiation and maintenance has the potential to facilitate intervention development. In terms of future unanswered research questions related to maintenance theory, this study uncovered additional themes (e.g. multiple goals and priorities) which are worth investigating to see if they should be explored in terms of maintained behaviour.

This study has employed a unique combination of research methods that could be further applied and its benefits and challenges could be researched in other populations, health behaviours and outcomes. Findings have shown that using real-time gathered data summaries has the potential to evoke meaningful narratives and build a rapport with participants. Future studies could use a similar design, employing EMA and experience sampling followed by qualitative assessment of other health-related behaviours, such as smoking or excessive alcohol

consumption. Future research questions could relate to the feasibility, usability and applicability of the DPI method in other health behaviours and other populations.

Furthermore, future research should also explore the best use of technology to assess human behaviour relating to WLM and potentially to intervene in real-time. A qualitative study component helps to understand motivations, desires and needs of a person maintaining weight. Thus, WLM-related interventions can focus on factors that a person has selected, tackling multiple determinants of WLM. Tailored interventions have the potential to provide personalised, scalable support facilitated by technology. Future research could reveal which predictions and which environmental factors are most relevant for each person in maintaining weight, with an aim to develop highly personalised WLM interventions.

## **5.6 Conclusions**

Taking into consideration modest long-term results of weight loss programmes, this study assessed factors which underpin WLM in people who have successfully lost weight. This study has shown that using a pre-specified theoretical framework, based on 100 theories that address behaviour maintenance, facilitated synthesis of qualitative data including photographs, notes, and interview narratives. Quantitative data regarding physical activity, weight, and other WLM-related constructs and cognitions, helped to inform the interviews. When presented with their data, participants often reported that they were likely to express characteristics associated with successful and unsuccessful weight loss maintainers. Goal conflict was one of the most frequently reported causes of relapse. What was

crucial to overall success on the WLM journey was allowing for times when the WLM plan is not strictly followed, and embracing a new, healthy lifestyle.

## **Chapter 6 Discussion: Multi-method approach to behaviour change maintenance focusing on weight loss maintenance.**

### **6.1 Overview of the chapter**

This thesis has described a multi-methodological approach to investigating behaviour change maintenance, focusing in particular on WLM. The previous chapters outlined specific methods that were applied to answer three specific research questions, with the overarching aim to advance the understanding of behavioural maintenance; and to facilitate the design of interventions to promote maintenance of health-related behaviour change.

Three specific research questions were addressed in this thesis:

1. What are the existing theoretical predictions and explanations of behaviour change maintenance?
2. What are the individual predictors of adherence/deviation to a self-imposed regime leading to WLM?
3. What are the advantages and disadvantages of using person-specific data in data-prompted interviews assessing WLM?

In this final chapter, the main findings obtained in relation to these research questions are discussed. The following sections focus on the overarching issues raised during the research process, as more detailed findings are covered at the end of individual chapters. The following discussion also includes a consideration of the strengths and limitations of the multi-methodological approach undertaken, as well

as outlining the key recommendations for policy and practice and future research questions arising from this thesis.

## **6.2 Summary and interpretation of key findings**

### **6.2.1 Question 1. What are the theoretical predictions and explanations of behaviour change maintenance?**

The systematic assessment of behavioural theories can facilitate the selection of theoretical explanations as an appropriate basis for the development of behavioural interventions. Whereas recent initiatives have focused primarily on *behaviour change* (R. Davis et al., 2014), the theory review conducted here (Chapter 2) analysed available theories focusing specifically on *behaviour maintenance*. Interestingly, it was found that most of the theories did not differentiate between the processes and cognitions involved in behaviour change/initiation, and those involved in the maintenance of behaviour (e.g., the Theory of Planned Behaviour; I. Ajzen, 1991), suggesting that behaviour change and maintenance are viewed as largely similar.

Several theories (Chapter 2) did point to qualitative differences between the explanations for behaviour initiation and maintenance. After thematic analysis of 100 included behavioural theories, five theoretical themes for behaviour change maintenance were specified. These included explanations relating to: (1) maintenance motives; (2) self-regulation; (3) psychological resources; (4) habits; and (5) environmental and social influences. The studies reported in Chapters 3 and 5 consequently included these five theoretical themes as a framework for assessing



behaviour change maintenance, specifically focusing on WLM. The theoretical themes showed a good fit for both the data correlations (Chapter 3) and for participants' narratives (Chapter 5).

In addition to these themes, however, the qualitative study conducted as part of this research points to maintenance-relevant explanations that were not covered in the assessed theories (Chapter 5). For example, study participants referred to goal conflict and to specific strategies within the self-regulation process, e.g. consciously allowing for lapses to occur. The maintenance process was often disrupted when other competing goals came into place. At these times, participants prioritised other life objectives that were perceived as more prominent than WLM at that particular time-point. Allowing this to happen was seen as a prominent part of maintaining change as long as getting back on track with WLM was on the agenda as soon as the competing goal had been achieved. In line with the observed positive association between allowing other goals to take priority and WLM, recent studies of goal conflict have also shown that other goals can have facilitating as well as interfering influences on the behavioural outcomes (Presseau et al., 2009; Presseau et al., 2008).

Another explanation for behavioural maintenance which was not included in the reviewed theories but which was derived from the observational research (Chapter 5), was consciously permitting for situations of low adherence to the WLM plan and compensating with increased self-regulation on the other occasions. According to Relapse Theory, people's self-efficacy decreases after the relapse, and subsequently

their ability to maintain health behaviour decreases (G. A. Marlatt & George, 1984). Contrary to this explanation, the results from this study suggest that occasionally allowing for lapses or even temporary relapses can enhance long-term behaviour maintenance, again providing that WLM and the necessary self-regulation strategies remain as a priority. Flexibility around goals and lapses is a necessary part of behaviour maintenance and realistically integrating WLM into everyday life. The importance of psychological flexibility in weight management has been acknowledged in studies (Stroebe et al., 2008) and in an increasingly popular counselling approach called Acceptance and Commitment Therapy (Hayes, Luoma, Bond, Masuda, & Lillis, 2006; Hayes, Strosahl, & Wilson, 1999). According to this approach people in order to maintain positive health change, have to accept that they will be in the situations that there are less likely to adhere to their health-related plans and that they need to allow for occasions when plans are not fully followed; however overall people need to commit to their long term goals.

Based on the presented findings, it is clear that specific theories of behavioural maintenance following initial change efforts are needed. A recent systematic review assessed the association between intervention effectiveness and the extent and type of theory use in diet and physical activity interventions (Prestwich et al., 2014). The results showed that out of 190 comparisons, 56% of interventions were based on a specific theory. However in 90% of the included interventions, the relationships between type and extent of theory use and effectiveness were only weak; the majority of these interventions included only one theory. One reason for

this may be that, in contrast to the common approach of using only a single theory, the one-theory-fits-all approach is often not appropriate, and even when using integrated cross-theoretical approaches to assess behaviours, some predictions still hold only in some individuals (Chapter 3).

The Medical Research Council guidance for the evaluation of complex interventions implies that best practice for developing behavioural interventions is to base them on appropriate theory (Craig et al., 2008). The guidance does not, however, specify how to best identify, apply, and develop such theory, or indeed how to combine theoretical constructs. The method adopted for the selection of the appropriate theory to underpin the research described in this thesis was admittedly labour intensive and therefore may not be possible in all contexts. Thus, there is a need for a searchable question-answering system that could be used to select and apply theoretical predictions in various contexts.

Consistent with this, further work is being undertaken by the Theory Project Team (<http://www.behaviourchangetheories.com/>) to assess over 1000 theoretical constructs and to provide a construct-searchable theory database. Yet, the findings of the current theory review (Chapter 2) suggest that additional conceptual work is needed not only to analyse and label specific constructs, but also to extract predictions and hypotheses regarding health behaviour from these theories. Online search engines 'learn' to find relevant information after typing in key words or questions (Najmi, Hashmi, Khazalah, & Malik, 2013). In a similar way, intervention developers and providers could use a searchable theory database where they can

find not only theoretical constructs, but also answers to conceptual questions (e.g., how to increase motivation). There are some suggestions regarding how to map theoretical constructs together with BCTs (Michie, Johnston, Francis, Hardeman, & Eccles, 2008). However, more guidance is needed on how to select appropriate theories and subsequently, how to choose specific theory-relevant techniques, as well as differentiating those relevant to behaviour change and behaviour maintenance.

### **6.2.2 Question 2. What are the individual predictors of adherence/deviation to a self-imposed regime leading to WLM?**

In this thesis, a cross-theoretical multi-methodological approach was presented to explore how individual predictions of behaviour change maintenance relate to behavioural outcomes. Multiple theoretical predictions of WLM were assessed, as was their association with three types of WLM outcomes: self-reported compliance with WLM plan; physical activity; and weight (Chapter 3). The presented findings showed that different predictions were significantly correlated with different WLM outcomes in different participants. Using a novel *N*-of-1 design allowed for the assessment of which factors were most important for different individuals. Large variability of predictors within and between individuals was found, suggesting that personally tailored WLM programmes may be desirable as opposed to non-tailored, one-size-fits-all methods. This theme was similarly echoed by participants in the qualitative interview study (Chapter 5). Overall, the large variability of predictions

leading to adherence or deviation to a self-imposed regime, strongly suggested that stratified, tailored WLM interventions are needed to optimise results.

Tailored health-interventions are personalised, relevant to the recipient, and received at the time when they are suitable and needed. Kroeze, Werkman, and Brug (2006) reviewed the literature on computer tailored interventions for physical activity and dietary behaviours. They showed that 3 out of 11 physical activity studies and 20 out of 26 nutrition-related studies found significant effects for tailored interventions, compared to control conditions that offered no tailoring, as assessed in RCTs. Although there is a wide range of literature reporting the effectiveness of tailored behavioural health-related interventions (for other systematic reviews see: Lustria, Cortese, Noar, & Glueckauf, 2009; Noar, Benac, & Harris, 2007), it is still not known how to best tailor interventions supporting WLM.

Chapters 3 and 5 showed that different variables were important for different individuals. For instance, some participants' WLM plan adherence was strongly correlated with WLM plan awareness; whereas in other participants their plan adherence was strongly correlated with the typicality of the environment and relying on the WLM routines, but not with the WLM plan awareness. Behavioural interventionists supporting WLM have a potential to gradually adapt practices used in advertising and marketing, employing targeted and time specific communication tools (Walsh, Rudd, Moeykens, & Moloney, 1993). In WLM, provided support should target different predictions that are shown to be influential. Thus, delivering support for people who are maintaining WLM should be based on the principles of

understanding which factors are relevant to the person in the given time. Temporal Self-Regulation Theory (P.A. Hall & Fong, 2007) suggests that people have different levels of self-regulatory capacity and different abilities with which to self-control their behaviours. The probability of engaging in particular behaviours is often related to motivation, underpinned by short term and long term goals. An example of a long term goal is living a long and healthy life, and maintaining a healthy BMI. An example of a short term goal could be enjoying a piece of cake after dinner. People often move between long term and short term goals when they decide on their actions. Therefore, future research should explore how to best identify goals that are relevant to the person in a given moment and how to best reinforce long-term health-related goals. Personalised support could use most recent technologies to support WLM including on-line platforms; phone or text messaging systems; mobile phone applications; monitoring devices including weight trackers; activity monitors and sensors; and social media. Further research needs to clarify how to tailor interventions accordingly to the cognitions that influence WLM outcomes.

### **6.2.3 Question 3. What are the advantages and disadvantages of using person-specific data in data-prompted interviews assessing WLM?**

This thesis presented various strengths and challenges of using person specific data in data-prompted interviews (DPIs). Chapter 3 included an explanation and quantitative analysis of person-specific WLM data. Data collection was prompted by the researcher (daily surveys sent at pre-specified times) and also by the participant (writing notes and taking pictures). Chapter 4 included a description of specific

features of health-related DPIs, and Chapter 5 reported outcomes of a WLM-relevant mixed data DPI. Across these different sources of data, it was found that the main feature of using person-specific data was stimulating participants' memory regarding specific events, perceptions, and states (similarly as reported by: Sheridan et al., 2011).

DPIs can result in the co-creation of knowledge by including participant's perspectives and reaction to their own individual ecological data (Kazi, Wohlfart, & Wolf, 2007). From the participant's perspective, presented data has the potential to guide discussion and allow them to formulate an informed reflection underpinned by the presented WLM data. From the researcher's perspective, DPI additionally allows for WLM data patterns to be explained and clarified. Using person-relevant data serves to enhance participants' memory for recent behavioural patterns and significant/relevant events and prepares them for the upcoming discussion.

In this thesis, mixed method approaches were used, and data triangulation, comparisons of data across various data sources, and methods were applied. The aim of using data triangulation was to highlight strengths of each approach, as they were used as ways to uncover deeper meaning within the data (Bradley, Curry, & Devers, 2007; Patton, 2002). As presented in this thesis, interconnected methods of WLM assessment showed pronounced differences between what participants perceived as relevant to their WLM, and what appeared as actually relevant in quantitatively assessed cross-correlations. For instance stress was not correlated with WLM plan adherence in most of the participants but interview accounts often

included references to the stressful situations that resulted in lapse. Analysing overlaps and discrepancies between the dataset (quantitatively and qualitatively) for each participant allowed to further disentangle the meanings of data collected within each dataset.

There were various challenges, associated with using person-specific data in WLM-related DPI, including practical, analytical, and ethical issues. Practical issues included data collection, and the selection and presentation of that data to the participants. In the research presented in this thesis (Chapter 5) data was collected using recent technology. Although the researcher tried to minimise the burden placed on participants, they nevertheless had to engage on a regular basis with the study by using the devices, filling in daily questionnaires, and sending 'experience samples'. By assessing both response rates and interview accounts, it became apparent that participants enjoyed engaging with new technologies (using devices), whereas completing daily questionnaires were associated with lower compliance (Chapter 3) and were described as more bothersome (Chapter 5). Technology supported *N-of-1* diary methods are used to explain why people differ in variability rather than mean level (Bolger, Davis, & Rafaeli, 2003). Thus, for cognitions that we are not yet able to measure with devices and sensors (such as motivation or confidence), frequent surveys remain the most applicable method.

Data selection and summary were also challenging, and complex issues had to be simplified and presented to the participants (Chapter 5). Some of the complexity of the data was not communicated to the participants, and data analyses required



specific research decisions and interpretations to be made. Interviews were not video recorded and subtle details of the encounters were not captured. Ethical challenges included concerns around data anonymity and sensitivity. Various pictures included participants, and their family members (often children) were excluded. For many participants, measures of their own weight and activity were considered very sensitive information. Thus, future interventions will need to carefully model which weight-related cognitions and outcomes participants are confident to share with interventionists and with other individuals, such as spouses or members of the weight support group.

### **6.3 Strengths of the research**

This thesis has several strengths, particularly from a theoretical and methodological viewpoint: the thorough use of a theoretical framework around which the study was designed, as well as allowing for new theoretical themes to emerge from the data. In particular, the theoretical themes provided an explanatory framework for the observations, and a number of variables were assessed in order to support or challenge the resultant theoretical predictions. In addition, new themes emerged regarding goal conflict, lifestyle change, and allowing for planned situations of non-adherence to the WLM plan (Chapter 5).

A further strength of this work is the use of multimodal technology based-methods, which allowed for the gathering of different types of data including quantitative ratings of assessed variables, qualitative notes, and pictures (Chapter 3 and 5). This comprehensive approach allowed the assessment of individual and contextual

variables related to WLM. Using validated wireless internet-connected scales and activity monitors provided objectively measured outcome data. The participant's device of choice was used for EMA, increasing compliance with an intensive behavioural observational study, which in turn allowed for full assessment of participants' characteristics and contexts.

#### **6.4 Limitations of the research**

The main limitations of this research included analytical challenges and the scalability of the applied design. Applying a time series analysis to behavioural research is a relatively novel method compared to other established designs and statistical approaches. There are ongoing debates considering how to best analyse *N-of-1* data (Cohen, Feinstein, Masuda, & Vowles, 2014). For example, there is controversy around the removal of autocorrelation from predictors and outcomes in order to statistically analyse the relationships between time series (Franklin, Allison, & Gorman, 2014; Kazdin, 2011), as well as disagreement on how best to assess data trends and summarise the vast datasets gathered in relation to each participant (Johnston & Johnston, 2013).

The *N-of-1* design put a large burden on the participants, who were asked to engage regularly with the study, by filling in daily questionnaires, sending experience samples and using the provided equipment. Although the design was useful to gather observational data, it was limited in terms of how scalable these procedures were if they were to be applied as an intervention tool. Current technology development and popularisation of wearable devices and sensors

(Barua et al., 2013; Gilmore et al., 2014) could make similar studies and follow-up interventions more convenient and more scalable. For instance by using Google Glasses or SmartWatches to collect individual level data, and subsequently to intervene in real-time (Holey & Gaikwad, 2014; Pascoe, 2006).

In the present study, participants reported that assessing several variables (not only weight but also activity, motivation and stress) allowed them to holistically explore their weight trajectories and associated cognitions. Engaging in several study activities was perceived as helpful in focusing on weight and 'staying on track'. Given the obesity epidemic that the NHS is currently facing, it may be worth considering how similar comprehensive technology-supported initiatives could provide an efficient resource that could lead to a reduction in the associated costs of treating obesity and its related conditions. For example, through maximising use of cost-effective online support, text messaging, mobile phone applications, and wearables, general practitioners could better support people to maintain their weight loss

## **6.5 Meaning of the study: possible mechanisms and implications for clinicians or policymakers**

There are various implications of this research for policy and practice. Specific implications of each individual study are described in the corresponding chapter. This section covers the overarching implications of the studies combined.

There is an urgent need for cost effective multidisciplinary-developed interventions that support people to maintain weight loss (Chapter 1). The research described here examined theoretical explanations of sustained behaviour (Chapter 2), tested these predictions within individuals (Chapter 3), developed novel methods to understand behaviour (Chapter 4) and provided evidence for new explanations for maintained behaviour (Chapter 5).

Currently in the UK, weight loss programmes are available free of charge for people who are classified as obese on the basis of their BMI (Department of Health, 2014). In contrast, very limited service options are available for people after weight management programmes have been completed. People tend to revert to their previous body weight in the first year after weight loss, and may regain even more than they have lost (Avenell et al., 2004). Thus, services should not only focus on weight loss, but also provide ongoing support to help people maintain a healthy weight.

Ongoing support could include enhancing maintained motivation, facilitating self-regulation (e.g., through self-monitoring), improving physical and psychological resources, developing healthy habits, and supporting healthy environments. Interventions could also help people to better manage multiple goals and promote occasional deviation from the strict WLM regime. Personalised interventions employing the most recent technology may also prove valuable to support people to maintain weight loss.

## 6.6 Unanswered questions and future research

There are several unanswered research questions derived from the research presented in this thesis. First, the themes presented in Chapter 2 and relationships between them should be further explored in WLM as well as in other maintained behaviours, such as medication adherence, and in other populations, for example young people. Chapter 3 showed that there are several differences within and between individuals in terms of the variables underpinning WLM. *N-of-1* trials allow researchers to test several predictions and combinations of techniques in a small sample of people without the need for a full scale RCT (Johnston & Johnston, 2013). Future research could apply experimental and randomised *N-of-1* trials to further explore WLM predictions and to intervene on the variables which are reported to influence outcomes, at the times when they are relevant.

Further research could also assess the potential for stratified behavioural interventions and assess which clusters of specific BCTs relating to which specific behavioural predictors are most effective in supporting people to maintain health behaviour. Future interventions could build on the five theoretical themes (Chapter 2) and could use available technology. For instance, by making use of social media to provide timely and relevant support (Eysenbach & Consort-Ehealth Group, 2011), social media-based WLM interventions could also create interpersonal accountability for sustaining weight loss.

Further application and improvement of DPs methods and assessment of the benefits and challenges associated with this research method would be beneficial

(Chapter 4). This could employ different data sources assessed within different populations and different health behaviours. The potential for knowledge co-creation (Kazi et al., 2007) could be explored from the participant perspectives in DPIs, participant engagement activities, and subsequently in the design of WLM interventions.

## **6.7 Concluding remarks**

Effective long-term health behaviour change requires both behaviour initiation and maintenance. This thesis assessed and summarised theoretical predictions for behaviour change maintenance and divided them into five specific and interconnected themes. The themes were subsequently used to explore WLM. The application of a multi-method approach allowed for the assessment of theoretical predictions in initially obese individuals who had recently lost a clinically significant amount of weight. This thesis provides a practical example of how multiple predictions can be assessed within people. Novel themes which were not mentioned in the existing behaviour change/maintenance theories emerged through the course of this research. Applying data to prompt narratives in the interviews showed that successful maintenance was often associated with allowing for temporal non-compliance with pre-imposed WLM regime. WLM was described as a lifestyle rather than a temporary undertaken set of behaviours.

## Appendix A Full search strategy

Full search strategy was informed by the Theory Project search strategy (Michie et al., 2014). The strategy replicated the Theory Project search (sets 1-3) adding maintenance specific terms (set 4), the results of the search were overlapped with results of the Theory Project search results and only additional new hits identified after adding maintenance-relevant items were screened (120 relevant records).

Search terms and structure was consistent across selected databases; limits were set in line with the exclusion criteria. Four sets of terms were used representing: set 1) theory terms which have only or predominantly been applied to changing behaviour; set 2) theory terms relevant to behaviour change but which have also been otherwise applied as theoretical tools to understanding behaviour more generally; set 3) change terms; set 4) maintenance relevant terms. The search string for the original electronic search was run across the three databases as follows:

**Set 1:** Behaviour change theory terms: “behavior change theories” OR “behavior change theory” OR “behavior theories” OR “behaviour change theories” OR “behaviour change theory” OR “behaviour theories” OR “diffusion of innovations” OR “elaboration likelihood model” OR “goal theory” OR “information motivation behavioral skills model” OR “information motivation behavioural skills model” OR “rational addiction model” OR “social cognition models”

**Set 2:** Behaviour theory terms: “acculturation theory” OR “AIDS risk reduction model” OR “behavior economic theories” OR “behaviour economic theories” OR “communication theory” OR “community organisation theory” OR “community

organization theory" OR "consumer information processing model" OR "control theory" OR "critical consciousness" OR "decisional balance theory" OR "ecological model" OR "ecological perspective" OR "empowerment theory" OR "enculturation theory" OR "exchange theory" OR "fear arousal theory" OR "goal setting theory" OR "goal theory" OR "habit theory" OR "health belief model" OR "health promotion theories" OR "health promotion theory" OR "health behaviour theory" OR "health behavior theory" OR "innovation-decision process" OR "interactionist model" OR "intrapersonal theory" OR "intrinsic motivation theories" OR "multicomponent stage model" OR "natural recovery" OR "operant learning theory" OR "operant theory" OR "organisational change theory" OR "organizational change theory" OR "personality theory" OR "precaution adoption process" OR "protection motivation theory" OR "reciprocal causality" OR "reciprocal determinism" OR "risk behaviour theory" OR "risk behavior theory" OR "self regulation theory" OR "self-regulation theory" OR "self-determination theory" OR "self-efficacy theory" OR "self-perception theory" OR "social capital" OR "social cognitive theory" OR "social comparison theory" OR "social determinism" OR "social influence" OR "social learning theories" OR "social learning theory" OR "social marketing theory" OR "social structural theory" OR "social support" OR "stage of change model" OR "stages of change model" OR "systems theory" OR "theories of planned behavior" OR "theories of planned behaviour" OR "theory of planned behavior" OR "theory of planned behaviour" OR "theory of reasoned action" OR "transtheoretical model" OR "value-expectancy theory"



**Set 3:** Change terms: "behaviour change" OR "behavior change" OR "behaviour modification" OR "behavior modification" OR "mediation effects on behaviour" OR "mediation effects on behavior" OR "normative change" OR "normative changes" OR "cultural change" OR "cultural changes" OR "social change" OR "social changes" OR "group level effect" OR "group level effects" OR "social development" or "social developments" OR "behavioural interventions" OR "behavioral interventions" OR "behavioural intervention" OR "behavioral intervention".

**Set 4:** Maintenance relevant terms: "maintenance" OR "behaviour maintenance" OR "behavior maintenance" OR "maintain" OR "sustain" OR "sustained behaviour" OR "sustained behavior" OR "sustained change" OR "habit" OR "habitual behaviour" OR "habitual behavior" OR "maintenance stage"

## Appendix B Theories assessed in the review

ID	Theory name and reference used	Theory intended application (according to theory authors)	If specific to maintenance; theme allocated	Behaviour specific (yes/no) if yes – which behaviour	Population specific (yes/no) if yes which population	Times suggested
1	Active living model (M. Stevens et al., 1999)	A behavioural change strategy for stimulating physical activity participation	<b>Motives</b> (enjoyment of behaviour)	Yes Leisure-time physical activity	Yes Sedentary older adults	0
2	Affect infusion model (Forgas, 1995, 2001)*	A comprehensive account of the role of affective states in social judgments	None	No	No	0
3	AIDS risk reduction model (Catania, Kegeles, & Coates, 1990)	A model of AIDS Risk Reduction Process	[Learning process ]	Yes Sexual behaviour; Learning	Yes Adults at risk of being infected with HIV	0
4	Attitude-social influence-efficacy model/integrated change model (H. De Vries et al., 2000; H. d. De Vries, Mesters, Steeg, & Honing, 2005)	A model of motivational change	[Motives]	Yes Health-related behaviour	No	2

5	Attribution theory (Jones, 1976)*	A theory of the process by which people form causal interpretations of the events around them	None	No	No	2
6	Behavioural Reasoning Theory (Westaby, 2005)	Extension of TPB, explains conscious behaviour	[Motives]	No	No	0
7	Belief systems theory (Rokeach, 1968)	A theory of organization and change within value-attitude systems	[Motives]	No	No	0
8	Classical conditioning (Skinner, 1953)	A learning theory; explains animal and human behaviour	[Learning process ]	Yes Learning	No	4
9	COM-B system (Susan Michie, Maartje M. van Stralen, et al., 2011)	A model of behaviour, also provides a basis for designing interventions aimed at behaviour change	[Motives; Resources and Environment]	No	No	0
10	Common Sense Model (Leventhal, Brissette, & Leventhal, 2003)	A model of illness representations	<b>Self-regulation</b> (coping)	No	No	3

11	Control theory (Carver & Scheier, 1982)	A theory explains how people perceive the environment they live in and how they react to the environmental changes	<b>Self-regulation</b>	No	No	2
12	Convergence of behaviour change models for AIDS risk reduction in Sub-Saharan Africa (Odutolu, 2005)	A comprehensive model of AIDS risk reduction theories in sub-Saharan Africa	[Motives, Environment, social influence and social change]	Yes Sexual behaviour	Yes People in sub-Saharan Africa	0
13	Demand-control model (job strain model) (Karasek, 1979)*	A model of the impact of the work environment on life outside the job	None	Yes behaviour performed within work environment	Yes People who work	0
14	Developmental causal model of the process of becoming a smoker (Flay, d'Avernas, Best, Kersell, & Ryan, 1983)	A model of a process of becoming a smoker	<b>Habit</b> [Learning process]	Yes Smoking	Yes Young people	0
15	Diffusion of innovations theory (E. M. Rogers, 2010)	A theory of diffusion of innovations	<b>Self-regulation</b> [Learning process]	Yes Adapting innovations	No	2

16	Dual process model of alcohol-behaviour link (Moss & Albery, 2009)	A dual process model of the alcohol-behaviour link for social drinking.	[Environment, social influence and social change]	Yes Drinking alcohol	No	0
17	Ecological model of health behaviours (McLeroy et al., 1988)	A model provides an ecological perspective on health promotion programs	[Environment, social influence and social change]	Yes Health-related behaviour	No	0
18	Ecological systems theory (Bronfenbrenner, 1977, 1986)	An ecological theory: person is embedded in the multilevel system which influences behaviour	[Environment, social influence and social change]	No	No	1
19	Elaboration likelihood model (Petty & Cacioppo, 1986)*	A general theory of persuasion	None	No	No	0
20	Extended information processing model (Flay, DiTecco, & Schlegel, 1980)*	A model of the extended human information processing including attention and memory.	None	No	No	0
21	Extended parallel process model (Witte, 1992)*	A theory of fear appeal	None	No	No	0
22	Family systems theory (Bowen, 1966)	A theory of family systems	[Environment, social influence and social change]	No	No	0

23	Goal theory (Bagozzi, 1992)	A theory explains the processes that occur between intentions and goal-directed behaviours	[Self-regulation]	No	No	0
24	Goal setting theory (Locke & Latham, 2002)	A theory based on Ryan's (1970) premise that conscious goals affect action	<b>Self-regulation</b>	No	No	2
25	Health action process approach (Schwarzer, 1992, 2008; Sniehotta et al., 2005)(Schwarzer, 1992; 2008)	A psychological theory of health behavior change	<b>Self-regulation</b> (coping)	Yes Health-related behaviour	No	<b>10</b>
26	Health behaviour goal model (Gebhardt, 1997)	A model is an attempt to describe and predict the process of behaviour change	[Motives]	Yes Health-related behaviour	No	0
27	Health belief model (Rosenstock, 1974)	A model of individual actions which should be taken to avoid a disease	[Motives]	Yes Health-related behaviour	No	3
28	Health Capital Theory (Grossman, 1972)*	Theory of health capital: health is a durable capital stock that produces an output of healthy time	None	Yes Health-related behaviour	No	0
29	Health-related model of behaviour change (Hunt & Martin, 1988)	A model of activities which are habitually performed and become routine	<b>Habit</b>	Yes Health-related behaviour	No	0

30	Information-motivation-behavioural skills model (Fisher, Fisher, Williams, & Malloy, 1994)	A model which is a conceptualization of AIDS-risk behaviour change	[Motives]	Yes Sexual behaviour	No	1
31	Integrated theoretical model for alcohol and drug prevention (Gonzalez, 1989)	A theory of alcohol and other drug abuse prevention for higher education	[Motives]	Yes Alcohol and drug use	Yes Students	0
32	Integration of Freire and protection motivation theory (Wallerstein & Sanchez-Merki, 1994)	A comprehensive adolescent social action program	[Motives]	Yes Learning	Yes People in educational settings	0
33	Integrative conceptual model of spiritual mechanisms underlying substance abuse behaviour change (Neff & MacMaster, 2005)	A framework for viewing substance abuse treatment and change in substance abuse behaviours during treatment	Environment, <b>social influence</b> and social change	Yes Substance abuse	Yes People who believe in God	0
34	Integrative model (Fishbein, 2000)	An integration of theories of behavioural prediction and behaviour change	[Motives]	Yes Sexual behaviour	No	0
35	Integrative Model of Health Attitude and Behaviour Change (Flay et al., 1983)	A model of the communication process	[Learning process ]	Yes Smoking	Yes Young people	0

36	Model of human occupation (Kielhofner, 2002)	A model of human volition, habituation and performance capacity	<b>Habit</b>	No	No	0
37	Multi-level/multi-media model of social change (Dresler-Hawke & Veer, 2006)	A model of behaviour, environmental change and public policy for healthy choices	[Environment, social influence and social change]	No	No	0
38	Needs-opportunities-abilities model (Gatersleben & Vlek, 1998)	A model of consumer behaviour	[Motives]	Yes Consumer behaviour	Yes Consumers	0
39	Net-present value economic theory (Wight, Abraham, & Scott, 1998)*	A theory used in economics to analyse potential investment	None	Yes Investment	No	0
40	Network theory of collective action (Heckathorn, 1990)	Theory of group-mediated social control	[Environment, social influence and social change]	No	No	0
41	Operant learning theory (Skinner, 1953)	Leading learning theory; explains reflective learning	[Learning process ]	No	No	2
42	Precaution adoption process model (Weinstein, 1988; Weinstein & Sandman, 1992)(Weinstein, 1988)	A stage theory of preventative behaviour	[Motives]	Yes Preventive behaviour	No	2



43	Pressure system model (David L. Katz, 2001)	A stage model for sequential assessments of the balance between resistance and motivation	<b>Self-regulation</b> (coping)	Yes Primary care	Yes Patients	0
44	PRIME theory of motivation (West & Brown, 2013)	The theory of motivation, including: plans, responses, impulses, motives and evaluations	[Motives]	No	No	0
45	Problem behaviour theory (Jessor & Jessor, 1977)	The theory of relationships between personality, perceived environment and behaviour	[Motives; Environment]	Yes Risk behaviours	Yes Young people	0
46	Protection motivation theory (R. W. Rogers, 1975; R. W. Rogers & Prentice-Dunn, 1997)	A theory of fear appeal	[Motives]	No	No	3
47	Prototype Willingness Model (Gerrard, Gibbons, Houlihan, Stock, & Pomery, 2008)	A model of decision making involved in health behavior	[Motives]	Yes Risk behaviours	Yes Young people	1
48	Reflective and impulsive model (Strack & Deutsch, 2004)	A dual process model including a reflective system and an impulsive system	<b>Self-regulation</b> <b>Habit</b> <b>Resources</b>	No	No	0
49	Regulatory fit theory (E.T. Higgins, 2006)	A theory of regulatory fit ('Fit makes people engage more strongly in what they are doing and feel right about it.')	<b>Motives</b> (satisfaction with behaviour)	No	No	0

50	Salutogenic model (Antonovsky, 1996)*	A model of a salutogenic orientation as the basis for health promotion	None	Yes Health promotion	No	0
51	Self-determination theory (Edward Lewis Deci & Ryan, 2002; Edward L. Deci & Ryan, 2010; Ryan & Deci, 2000)	A theory of the processes through which a person acquires the motivation for initiating new health-related behaviours and maintaining them over time	<b>Motives</b> (satisfaction with outcomes)	Yes Health-related behaviours	No	<b>7</b>
52	Self-efficacy theory (Albert Bandura, 1977)	A theory of perceived self-efficacy	[Motives]	No	No	0
53	Self-perception theory (D. J. Bem, 1967, 1972)	A theory of self-attitudes	<b>Motives</b> (identity)	No	No	0
54	Self-regulation theory (F.H. Kanfer & Gaelick-Buys, 1991)	A theory of the initial stages of behaviour change, focusing on the detection of maladaptive behaviour and the early sources of motivation for change	<b>Self-regulation</b>	No	No	0
55	Six staged model of communication effects (Vaughan & Rogers, 2000)	A model of the adoption of family planning methods	<b>Motives</b> (satisfaction with outcomes)	Yes Family planning	Yes Young people	0

56	Social action theory (Ewart, 1991)	An integrative action schema for defining public health goals and identifying changeable influences to encourage self-protective activities	[Environment, social influence and social change]	Yes Health-related behaviours	No	0
57	Social change theory (B. Thompson & Kinne, 1990)	A theory for changing community norms about health related behaviour	Environment, social influence and <b>social change</b>	No	No	0
58	Social change theory of dialogue and praxis (Papa, Singhal, & Papa, 2006)*	A theory of community organisation and social change explaining dialogue and praxis	None	No	No	0
59	Social cognitive/learning theory (A. Bandura, 1986)	An interactional model of causation in which environmental events, personal factors, and behavior all operate as interacting determinants of each other	Environment, <b>social influence</b> and social change	No	No	<b>9</b>
60	Social consensus model of health education (Romer & Hornik, 1992)	A model of social consensus in behaviour change for HIV prevention	[Environment, social influence and social change]	Yes Sexual behaviours	Yes Young people	0

61	Social development model (Hawkins & Weis, 1985)	A model of delinquency prevention derived from integrating control and social learning theories	[Environment, social influence and social change]	Yes 'Delinquent behaviour'	Yes Young people	0
62	Social ecological model of health promotion (Stokols, 1992)	A model of the development of effective strategies to promote personal and collective well-being	[Environment, social influence and social change]	Yes Health promotion	No	0
63	Social ecological model of walking (Alfonzo, 2005)	A model for the decision-making process of walking	[Environment, social influence and social change]	Yes Walking	No	0
64	Social ecology model of behaviour change (Panter-Brick et al., 2006)	A social ecology perspective to make explicit the links between intention to change, actual behaviour change, and subsequent health impact	[Environment, social influence and social change]	No	No	0
65	Social identity model (Tajfel & Turner, 1979)	The theory defines 'social identity'	[Environment, social influence and social change]	No	No	1

66	Social norms theory (Berkowitz, 2004)	A theory of social norms which has implications for health promotion and prevention	[Motives; Environment, social support and social change]	Yes Health promotion and prevention	No	0
67	Technology acceptance model 1 (F. D. Davis, 1989)	A model of technology acceptance	[Motives]	Yes Technology acceptance	No	0
68	Technology acceptance model 2 (Venkatesh & Davis, 2000)	A model of technology acceptance	[Motives]	Yes Technology acceptance	No	0
69	Technology acceptance model 3 (Venkatesh & Bala, 2008)	A model of technology acceptance	<b>Motives</b> (satisfaction with outcomes)	Yes Technology acceptance	No	0
70	Temporal self-regulation model (P.A. Hall & Fong, 2007)	A theory focusing on the capacity to engage in behaviour	<b>Motives</b> (satisfaction with outcomes)	No	No	0
71	Theoretical framework for behaviour change (Burnet, Plaut, Courtney, & Chin, 2002)	A framework for environmental influences on behaviour as well as intrapersonal determinants	[Motives; Environment, social support and social change]	Yes Diabetes prevention	Yes Young people	0

72	Theories of reasoned action/theory of planned behaviour (Icek Ajzen, 1985; Fishbein & Ajzen, 1975)	A theory designed to predict volitional behaviours and to understand their psychological determinants	[Motives; Environment, social support and social change]	No	No	4
73	Theory of change (Lewin, 1951)	A theory which describes change as 'an on-going social process'	[Environment, social support and social change]	No	No	0
74	Theory of interpersonal behaviour (Triandis, 1977)	A theory of interpersonal behaviour	<b>Self-regulation Habit</b>	No	No	0
75	Theory of rational addiction (Becker & Murphy, 1988)*	A theory of rational addiction: addictions (to heroin, tobacco, television, etc.) can be usefully modelled as specific kinds of rational, forward-looking, optimal consumption plans	None	Yes Addictive behaviours	No	0
76	Transcontextual model of motivation (Martin S. Hagger, Chatzisarantis, Culverhouse, & Biddle, 2003)	a theory of social cognition to explain the psychological processes by which young people transfer motivation during physical education into physical activity behaviour during leisure time	[Motives]	Yes Exercise	Yes Young people	0

77	Transtheoretical/stages of change model (Prochaska & Di Clemente, 1983; Prochaska et al., 1992)	A theory which originally emerged from a comparative analysis of 18 leading therapy systems	Environment, <b>social influence</b> and social change	Yes Smoking	No	<b>11</b>
78	Unified Theory of Acceptance and Use of Technology (Venkatesh, Morris, Davis, & Davis, 2003)	A theory of acceptance and use of technology	[Motives]	Yes Acceptance and Use of Technology	No	0
79	Utility Theory (Fishburn, 1968)*	A theory of people's preferences or values and assumptions about a person's preferences that enable them to be represented in numerically useful ways	None	No	No	0
80	Yale information processing model (McGuire, 1976)*	A model of the variables that might influence comprehension, acceptance, and retention of persuasive messages	None	No	No	0
81	Model of Behaviour Maintenance (A. J. Rothman, 2000; A.J. Rothman et al., 2004)	A theory of behaviour change maintenance	<b>Motives</b> (satisfaction with outcomes)	No	No	<b>8</b>

82	Relapse Prevention Theory (G. Alan Marlatt & Donovan, 2005; G. A. Marlatt & George, 1984)	A theory of preventing relapse and coping with situational barriers	<b>Self-regulation</b> (coping)	Yes Health behaviour (preventing relapse)	No	<b>9</b>
83	Strength Model of Self-Control (Baumeister et al., 1998; Baumeister et al., 2000; Muraven & Baumeister, 2000)	A theory of self-regulation as a limited cognitive resource	<b>Resources</b>	No	No	0
84	Goal Conflict Model (Stroebe et al., 2008)	A theory of eating regulation	<b>Resources</b>	Yes Eating (dieting)	No	1
85	Habit Theory (B. Verplanken, 2006; B. Verplanken & Aarts, 1999; B. Verplanken & Orbell, 2003; B. Verplanken et al., 2008)	A theory of habit; habit is defined as a psychological construct, rather than simply past behavioural frequency; refers to 'habitual mind-sets'	<b>Habit</b>	Yes Habitual behaviours	No	<b>6</b>
86	Theory of Physical Activity Maintenance (Nigg, Borrelli, Maddock, & Dishman, 2008)	A theory of physical activity maintenance	<b>Motives</b> <b>Self-regulation</b> (coping)	Yes Physical activity	No	3



87	Rubicon Model of Action Phases (Heckhausen, 2007)	A stage model of behaviour which is divided into two phases: a motivation phase and a volition phase	<b>Self-regulation</b>	No	No	2
88	Intrinsic motivation and cognitive evaluation theory (Hoss, 1985)*	A theory of self-motivation and underlying cognitive processes	None	No	No	0
89	Two-factor avoidance theory (Stasiewicz & Maisto, 1993)	A learning-based explanation of the role of negative affect in the maintenance of substance use disorder	[Learning process ]	Yes Substance use	No	0
90	The dietary restraint theory (Polivy & Herman, 1985)	A theory of eating regulation	<b>Resources</b>	Yes Eating (dieting)	No	0
91	Process Model of Lifestyle Behaviour Change (C. Greaves et al., 2010)	A process model for supporting a lifestyle behaviour change	<b>Self-regulation</b> (coping) <b>Habit</b>	Yes Health-related behaviour	No	1
92	Self-Schema Theory (Markus, 1977)	A theory of 'self-schema' - the beliefs and ideas people have about themselves	<b>Motives</b> (identity)	No	No	1

93	Habit and intention theory (Ouellette & Wood, 1998)	A theory of habit	<b>Habit</b>	Yes Health-related behaviours	No	2
94	Selection, Optimisation and Compensation model (Baltes, 1997)	A model of successful development and aging	<b>Resources</b>	Yes Aging	Yes Older people	1
95	Normalisation Process Theory (C. May & Finch, 2009; C. R. May et al., 2009)	A set of sociological tools to explain how new or modified practices are operationalized in healthcare and other institutional settings	<b>Environment, social influence and social change</b>	Yes Health care	Yes Population within health-care and other institutional settings	1
96	RE-AIM framework (Glasgow, Vogt, & Boles, 1999)*	A sociological framework for designing interventions	None	Yes Health-related behaviours	No	1
97	Dual process model of self-control (Friese et al., 2008; Hofmann et al., 2008)	A model of impulsive and reflective influences on health behaviour	<b>Resources Self-regulation Habits</b>	Yes Health-related behaviours	No	2
98	Model of engagement in medical rehabilitation (Lequerica & Kortte, 2010)	A model of patient engagement in rehabilitation	<b>Self-regulation</b>	Yes Rehabilitation	Yes Patients	1

99	Three-factor model to guide practice (DiMatteo, Haskard-Zolnierrek, & Martin, 2012)	A brief narrative review of research on (non)adherence and three-factor heuristic model to guide practitioners	<b>Self-regulation</b> (coping) Social influence	Yes Medical non-adherence	Yes Patients	1
100	A 2 x 2 behaviour change matrix (A. J. Rothman et al., 2009)	A theory decomposing action control and behavior change into a 2 (reflective, automatic) x2 (initiation, maintenance) matrix	<b>Motives</b> (satisfaction with outcomes)	Yes Food choice	No	2
101	Coping planning (Sniehotta et al., 2005)	A theory of the mental simulation of overcoming anticipated barriers to action.	<b>Self-regulation</b> (coping)	Yes Health-related behaviour	No	3
102	PIT Pavlovian Instrumental Transfer (Balleine & Killcross, 2006; Corbit & Balleine, 2005)	A learning theory: in instrumental conditioning, presentation of a reinforcer is contingent upon the performance of a specific action by the subject	[Learning process ]	Yes Learning	No	1
103	Associative theories of goal-directed behaviour (de Wit & Dickinson, 2009)	A theory of human decision-making	[Learning process ]	Yes Learning	No	1
104	Population-Based Health Promotion Model (McKinlay, 1995)	An environmental model focusing on PA in sedentary older adults	[Motives; Environment, social support and social change]	Yes Physical activity	Yes Sedentary older adults	1

105	The operation of the basal ganglia (Graybiel, 1995, 2005)	A learning neuronal model: basal ganglia are critically involved in building up sequences of behavior into meaningful, goal-directed action	[Learning process ]	Yes Learning	No	1
106	Revision and persistence (Jeffrey B. Vancouver & Kendall, 2006; Jeffery B. Vancouver, Thompson, Tischner, & Putka, 2002)	A theory of behavioural goals defined as internal representations of desired states	[Motives]	No	No	1
107	Organizational change theory (Cummings & Worley, 2014)	A theory of organization development intervention	[Environment, social support and social change]	Yes Organizational change	Yes People within the organisation	1
108	Self-regulatory theories (Boekaerts, 1997)	A theory of self-regulated learning	[Self-regulation]	Yes Learning	No	1
109	A Behavioral Model of Medication Adherence (De Bruin et al., 2005)	A behavioural model of medication adherence	<b>Self-regulation Motives</b> (satisfaction with outcomes)	Yes adherence	Yes Patients	2
110	Self-Concept Theory (Bracken, 1996)	A theory of self-perception	<b>Motives</b> (identity)	No	No	1

111	A learning theory perspective on lapse, relapse, and the maintenance of behavior change (Bouton, 2000)	A learning theory perspective on lapse, relapse, and the maintenance of behavior change	<b>Self-regulation</b> (coping) [Learning process ]	Yes Learning	No	1
112	Health Behavior Internalization Model (Bellg, 2003)	A model of motivational factors associated with internalization processes	<b>Motives</b> (identity)	Yes Health-related behaviour	No	2
113	Angelo (B. Swinburn et al., 1999)*	An environmental framework focusing on behavior sustainability factors: analysis grid for environments linked to obesity	[Environment, social support and social change]	Yes Eating	Yes Obese people	1
114	Social Determinants of Health and Environmental Health Promotion Model (Schulz & Northridge, 2004)	A conceptual framework for environmental health promotion	[Environment, social support and social change]	Yes Health-related behaviour	No	1
115	Environmental Research Framework for Weight Gain Prevention (Kremers et al., 2006)*	An environmental research framework for weight gain prevention; A dual-process model	[Environment, social support and social change]	Yes Eating	No	1
116	Life crises and the process of reinvention theory (Epiphaniou & Ogden, 2010; Ogden & Hills, 2008)	A theory of sustained behavior change triggered by a significant life crisis relating to health, relationships or salient milestones	<b>Motives</b> (life changing events)	Yes Health-related behaviour	No	2

117	The strength model of self-control (M. S. Hagger et al., 2009)	The strength model of self-regulation failure and health-related behaviour	<b>Resources and self-regulation</b>	Yes Health-related behaviour	No	1
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*Note.* Themes which are written in the square brackets refer to the theories which fit perfectly into our theory review themes but give equal explanations/predictions for behaviour initiation and behaviour maintenance. Times suggested: How many times suggested by theory experts. Theories marked with star were not included in thematic analysis (reasons explained in text).

## Appendix C Theory theme validation exercise

Instructions: Thank you very much for agreeing to take part in this theme validation exercise. This task should take about 15 minutes. Please read the theme definitions carefully.

Short theme definitions

- A. **Motives** – reasons why people engage in behaviour.
- B. **Resources** – psychological and physical assets that someone can draw on in order to engage in behaviour.
- C. **Self-regulation** – ability to actively control behaviour; ability to override or inhibit behaviours, urges, emotions or desires that would otherwise hinder goal-directed behaviour.
- D. **Habits** - behavioural patterns, based on context-behaviour associations which are learned through context-dependent repetition. They are elicited automatically when associated contexts are encountered.
- E. **Environment and social influences**- the setting or conditions in which a particular activity is carried on; these may include social settings, social support and social change.

Please allocate each extracted theory statement to the theme it fits in (in your opinion). You can allocate one statement to more than one theme.

Statements examples

1. 'The social reinforcements obtained from smoking are probably the most important influence on whether or not an experimenting adolescent will become a regular smoker. Peer pressure still may play a role at this stage, although its effects probably are mediated through social reinforcement.'
2. 'We consider various mechanisms that could underlie the habitual control of action, and we conclude that direct cuing and motivated contexts best account for the characteristic features of habit responding—in particular, for the rigid repetition of action that can be initiated without intention and that runs to completion with minimal conscious control'
3. 'The term self-schema refers to the beliefs and ideas people have about themselves. These beliefs are used to guide and organize information processing, especially when the information is significant to the self. Self-schemas are important to a person's overall self-concept. The term schematic describes having a particular schema for a particular dimension. For instance, a person in a rock band at night would have a "rocker" schema. However, during the day, if he works as a salesperson, he would have a "salesperson" schema during that period of time.'
4. 'The authors review evidence that self-control may consume a limited resource. Exerting self-control may consume self-control strength, reducing the amount of strength available for subsequent self-control efforts. Coping with stress, regulating negative affect, and resisting temptations require self-control, and after such self-control efforts, subsequent attempts at self-



control are more likely to fail. Continuous self-control efforts, such as vigilance, also degrade over time.'

5. '[...] relapse is not viewed merely as an indicator of treatment failure. Instead, potential and actual episodes are key targets for both proactive and reactive intervention strategies. RP treatment procedures include specific intervention techniques designed to teach the individual to effectively anticipate and cope with potential relapse situations.'
6. 'Decisions regarding behavioral initiation are predicted to depend on favorable expectations regarding future outcomes, whereas decisions regarding behavioral maintenance are predicted to depend on perceived satisfaction with received outcomes.'
7. 'In our model we also assume that a warm, trusting relationship is a precondition not only for therapy but for any of the helping professions. If clients feel that the professional does not care about them or if they do not trust the professional to adequately care for their needs, then clients are obviously more likely to terminate the helping relationship rather quickly'
8. 'Just as preparation for action was essential for success, so too was preparation for maintenance. Successful maintenance builds on each of the processes that came before. Specific preparation for maintenance entailed an assessment of the conditions under which a person was likely to relapse and development of alternative responses for coping with such conditions without resorting to self-defeating defences and pathological responses.'

9. 'There also appears to be general agreement among therapists, but less conclusive support, that motivation for change is a key precondition for therapy.'
10. '[...] under conditions of low control resources, automatic affective reactions toward tempting stimuli should exert a stronger influence on health behavior than under conditions of full resource availability. In a complementary manner, the impact of reasoned attitudes or restraint standards should be stronger under full resources and wane with increasing processing strain on reflective operations.'
11. 'Whereas behavioral initiation is thought to be based on expectations about future outcomes, the decision to maintain an adopted pattern of behavior is thought to be based on people's satisfaction with the outcomes they have obtained. The guiding premise is that people will maintain a change in behavior only if they are satisfied with what they have accomplished.'
12. 'I proposed that people experience regulatory fit when the manner of their engagement in an activity sustains (rather than disrupts) their current motivational orientation or interests. Fit makes people engage more strongly in what they are doing and feel right about it. Individuals, for example, can pursue the same goal with different orientations and in different ways.'
13. 'Intrinsic motivation involves doing a behaviour because the activity itself is interesting and spontaneously satisfying. When intrinsically motivated, people perform activities because of the positive feelings resulting from the

activities themselves. People are interested in what they are doing, and they display curiosity, explore novel stimuli, and work to master optimal challenges.'

14. 'Participants with higher levels of coping planning after discharge were more likely to report higher levels of exercise four months after discharge.'
15. 'Failures to change do not necessarily indicate poor willpower or insufficient understanding of health issues but instead the power of situations to trigger past responses. Habits keep us doing what we have always done, despite our best intentions to act otherwise.'
16. 'The family is a system in that a change in one part of the system is followed by compensatory change in other parts of the system.'
17. 'A habit seems to be accompanied by an enduring cognitive orientation, which we refer to as "habitual mind-set" that makes an individual less attentive to new information and courses of action, and thus contributes to the maintenance of habitual behaviour.'
18. 'People with high goals produce more because they are dissatisfied with less. The bar for their satisfaction is set at a high level. This is why they are motivated to do more than those with easy goals.'
19. 'Studies in psychophysiology and cognitive psychology provide evidence that activities which are habitually performed become "routine" in such a way that higher levels of cognitive processing is, for most of the time, unnecessary. Such activities are, therefore, carried out with minimum awareness, coming to the forefront of consciousness only occasionally.'

20. 'In later stages of the process, as the individual incorporates these cognitive changes and acquires behaviour change skills and behavioural intention to change, peer influence processes become increasingly important in reinforcing behavioural changes.'

Please answer the following questions:

1. Do you have a degree in Health Psychology?

Yes

No

2. Are you...

A PhD student

Researcher

Academic

Other, please specify: \_\_\_\_\_

Thank you very much for taking part!

## Appendix D Introductory session materials

### Weight management study checklist: Am I eligible to take part?

1. Have you recently lost 5% and more of your body weight? (We are looking for people who were overweight and successfully lost a minimum 5% of body weight)
  - Yes
  - No
2. Do you have a pacemaker or other internal medical device?
  - Yes
  - No
3. Are you pregnant or planning to be pregnant in the near future? (Next two months)
  - Yes
  - No
4. Are you a SmartPhone user? (iPhone, any Android phone, Blackberry etc)
  - Yes
  - No
5. Do you use your phone regularly?
  - Yes
  - No
6. Do you have Internet on the mobile phone?
  - Yes
  - No
7. Do you have Wi-Fi at home?
  - Yes
  - No

Please see our eligibility criteria to determine if you can take part in this study.



### Weight management study for people who have recently lost weight

**Congratulations on your weight loss success!!!**



The Centre for Translational  
Research in Public Health



## You've chosen Interactive study. What happens next?

The study facilitator will explain all the study procedures to you and will check that you are still happy to take part. The study will consist of three parts:



1. Daily feedback form sent to your mobile phone.
2. Capturing your experiences by taking pictures, writing notes, etc.
3. Tracking your weight and physical activity with Fitbits.

All three parts are further explained below; please feel free to ask questions if you want to clarify anything.

**Contact:** Dominika Kwasnicka Newcastle University  
PhD candidate [d.kwasnicka@ncl.ac.uk](mailto:d.kwasnicka@ncl.ac.uk)  
Tel: 07988806776 or 0 191 222 8892  
Institute of Health & Society, Newcastle University  
The Baddiley-Clark Building, Richardson Road  
Newcastle upon Tyne, NE2 4A



### 1. Daily feedback form sent to your mobile phone

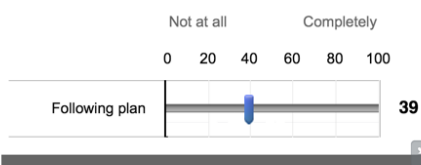
We will send you a daily survey which assesses your experiences at a time pre-specified by you. Questions will be repeated daily. We will ask about your mood, motivation to maintain your weight, etc. and about one specific factor which relates to your weight. Can you think of one specific issue which has an impact on your weight maintenance and which changes daily? \_\_\_\_\_

Your morning feedback form will be delivered at \_\_\_\_\_ o'clock

And your evening feedback form will be delivered at \_\_\_\_\_ o'clock

Your first survey will be delivered on \_\_\_\_\_ (date)

How much have you followed your weight maintenance plan?



This is how the feedback form will look on your mobile screen.

## 2. Capturing your experiences

We would like to follow your daily experiences of maintaining weight. We would like to see what makes your weight maintenance successful and in addition we would like to see the challenges you may face while maintaining your weight. Therefore, we will ask you to capture these experiences by:

- Taking pictures
- Writing notes
- Making short videos (up to 1 minute)

Please send them to:

\_\_\_\_\_

We can also set up a private password-protected 'experience blog' for you so that we can follow you on your weight maintenance journey.



## 3. Measuring your weight and physical activity with Fitbits

We will ask you to wear a 'Fitbit One' activity monitor and to synchronise it at least twice a week. Tracking your activity motivates you to stay active and allows you to monitor your progress. There are various options of wearing your Fitbit:

### How to wear your Fitbit One



To prevent losing your tracker, wear it:

- 1 in your pocket
- 2 clipped on your pocket facing inward
- 3 clipped on your bra



Which one do you think will be the most suitable for you? \_\_\_\_\_ (1, 2 or 3)

Do you think you will use the sleep monitor feature?  Yes  No

## Cont. Measuring your weight and physical activity with Fitbits

We will provide you with a Fitbit Aria scale and we will ask you to weigh yourself daily.

Think of the most suitable time and place to weigh yourself, e.g. *I will weigh myself before taking a shower in the morning.*

I will weigh myself \_\_\_\_\_(when?)\_\_\_\_\_ (where?) every day.

Fitbit Aria measures your weight as well as your body fat % and BMI.

### What's body fat percentage?

Body fat is essential to maintaining good health.

For most women, 14-31% is a healthy range.

For men, that range is closer to 6-24%.

### What's BMI?

BMI stands for body mass index.

It looks at body fat in relation to height and weight and tells you if you're in the healthy range.



We will show you how to set up and use the Fitbit One activity monitor and the Fitbit Aria scale.

## Final details: What else do I need to know about this study?

- ✓ Your study participation is **voluntary** and you can opt out of the study at any point.
- ✓ Initially we will ask you to participate for **2months** but your study participation can be extended for up to 6 months (that's entirely up to you).
- ✓ We will never disclose your weight or any other study data; your personal information will be anonymous.
- ✓ You will be free to use Fitbit equipment during the study duration.
- ✓ After 2 months of study participation, you will receive a **face-to-face interview** summarising your personal experiences of losing weight.
- ✓ You are free to contact the main study investigator at any point during the study if you have any issues or concerns.

**Thank you for your participation!!!**

**Please get in touch if you have any questions!**





## Appendix E Consent form

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet.	<input type="checkbox"/>
2.	I have been given the opportunity to ask questions about the project and my participation.	<input type="checkbox"/>
3.	I voluntarily agree to participate in the project.	<input type="checkbox"/>
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	<input type="checkbox"/>
5.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data, etc.) to me.	<input type="checkbox"/>
6.	If applicable, separate terms of consent for interviews, audio, video or other forms of data collection have been explained and provided to me.	<input type="checkbox"/>
7.	The use of the data in research, publications, sharing and archiving has been explained to me.	<input type="checkbox"/>
8.	I understand that other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form.	<input type="checkbox"/>
9.	Select only <b>one</b> of the following: <ul style="list-style-type: none"> <li>• I would like my name used and understand what I have said or written as part of this study will be used in reports, publications and other research outputs so that anything I have contributed to this project can be recognised.</li> <li>• I do not want my name used in this project.</li> </ul>	<input type="checkbox"/>
		<input type="checkbox"/>
10.	I, along with the Researcher, agree to sign and date this informed consent form.	<input type="checkbox"/>

**Participant:**

\_\_\_\_\_  
Name of Participant

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

**Researcher:**

Dominika Kwasnicka  
Name of Researcher

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

## Appendix F Example report 2 months

# Weight Maintenance Study

## Personal Report



*Success is only a starting point.  
Maintenance is a lifelong journey.*

Interview date: 7<sup>th</sup> January 2014

Time period covered in the report: 31<sup>st</sup> October – 31<sup>st</sup> December 2013  
(2 months)



**fuse**

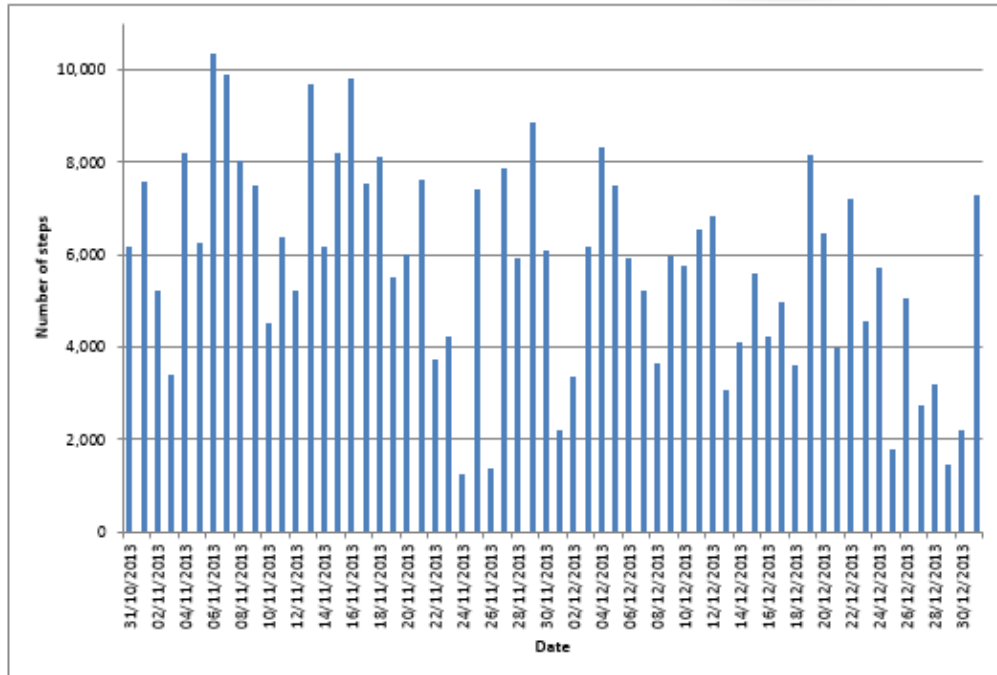
The Centre for Translational  
Research in Public Health



## Your daily activity summary

### Steps

This graph shows the number of steps you have taken each day:



- ❖ On average you have taken **5,760** steps per day (number will be higher if we added step count from days when you have not worn activity monitor). The recommended daily steps challenge is 10,000 steps per day<sup>1</sup>.
- ❖ Your average number of steps on weekdays is 6,157 per day. Your average number of steps at weekends is 4,787 per day. You seem to do somewhat fewer steps on weekend days than on weekdays.
- ❖ Your average number of calories burned per day is 1,714 with 732 activity calories.
- ❖ Your self-reported sleep time is on average about 7 hours per night.

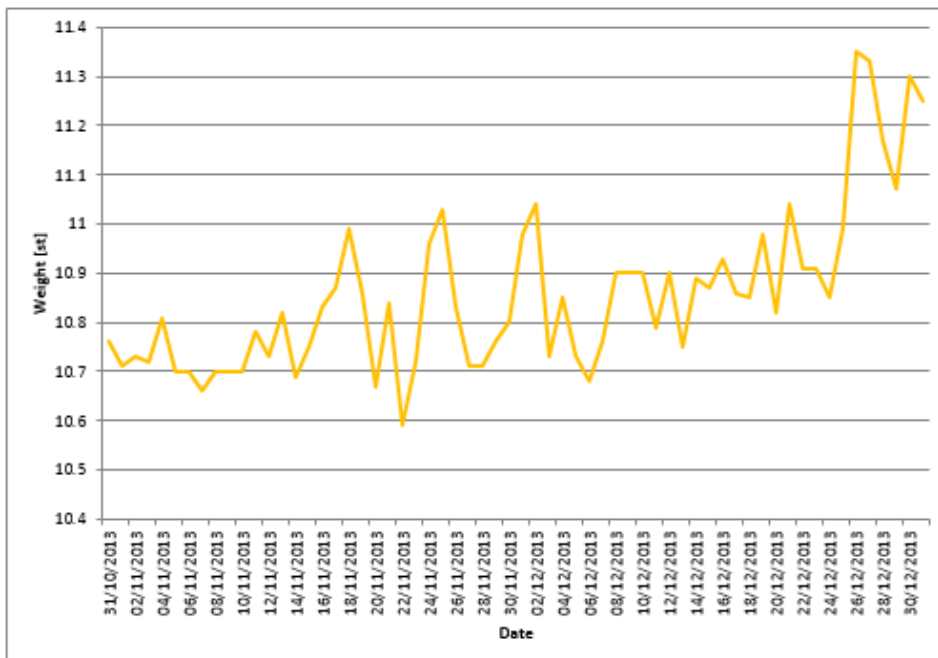
<sup>1</sup> NHS choices: <http://www.nhs.uk/Livewell/loseweight/Pages/10000stepschallenge.aspx>

## Your daily weighing summary

### Weight



- ❖ Your weight at the start was **10.76 st.**
- ❖ Your weight at two months was **11.25 st.**
- ❖ This means that you managed to successfully maintain your weight loss with some relatively small weight fluctuations and with a small weight increase.
- ❖ Your average body fat % is 35.17%, which is slightly outside a healthy range (for women, it is 14-31%).
- ❖ Your average BMI is **26.08**; you can calculate it on 'NHS choices' website and check if you are in a healthy BMI range.



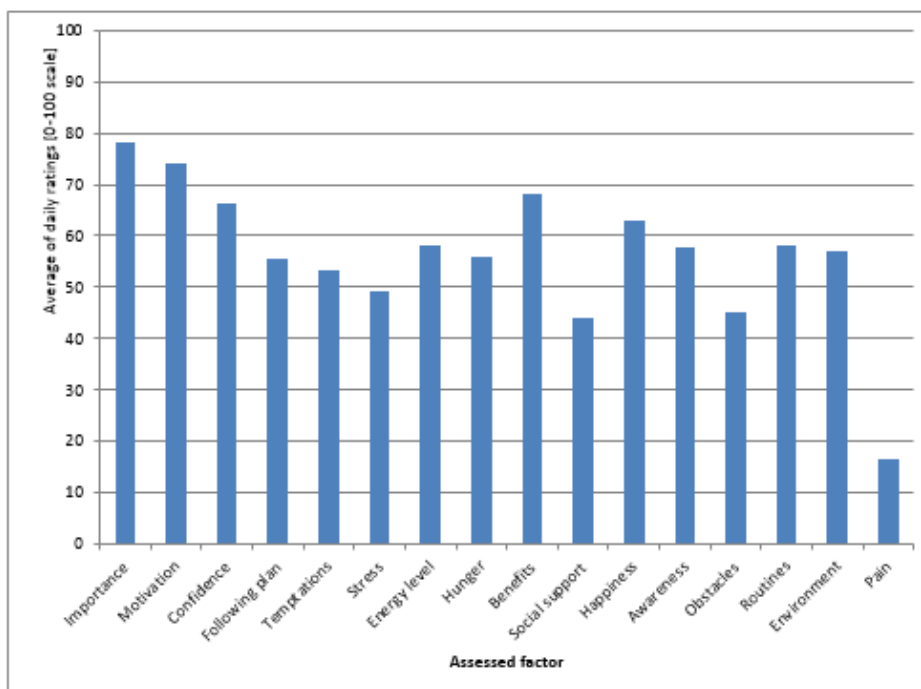
## Factors which influence your weight maintenance

### Average score for each factor assessed

You have told us about the factors that have influenced your weight maintenance over the last two months. The graph below summarises the average score for each factor.

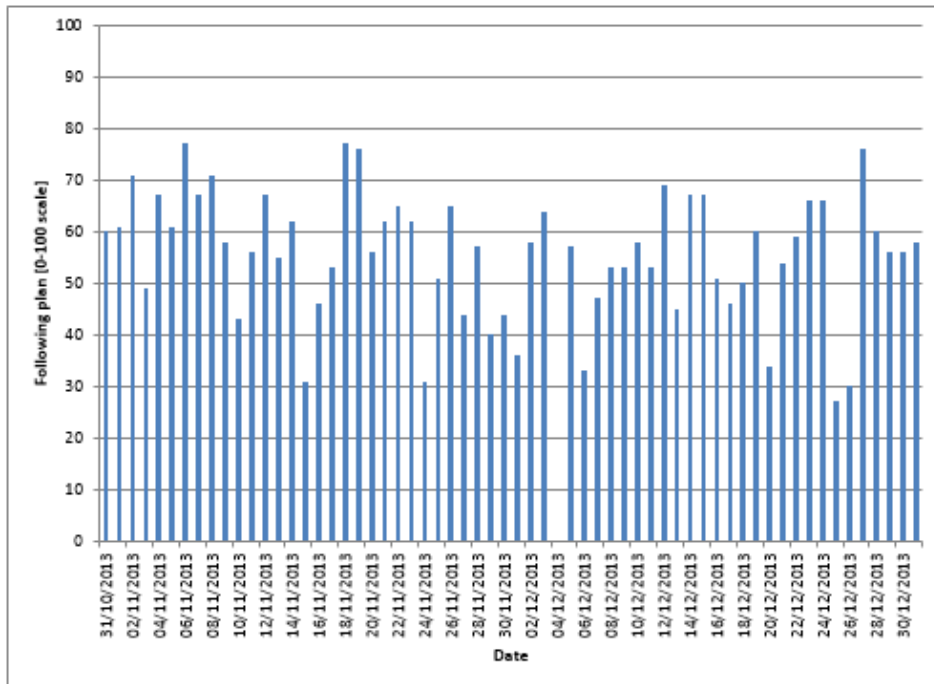
Factors on average rated higher were:

- ❖ Importance of your weight loss maintenance plan compared to other things you want to do
- ❖ Motivation to follow your weight maintenance plan
- ❖ Benefits of your weight loss



### Following your weight maintenance plan

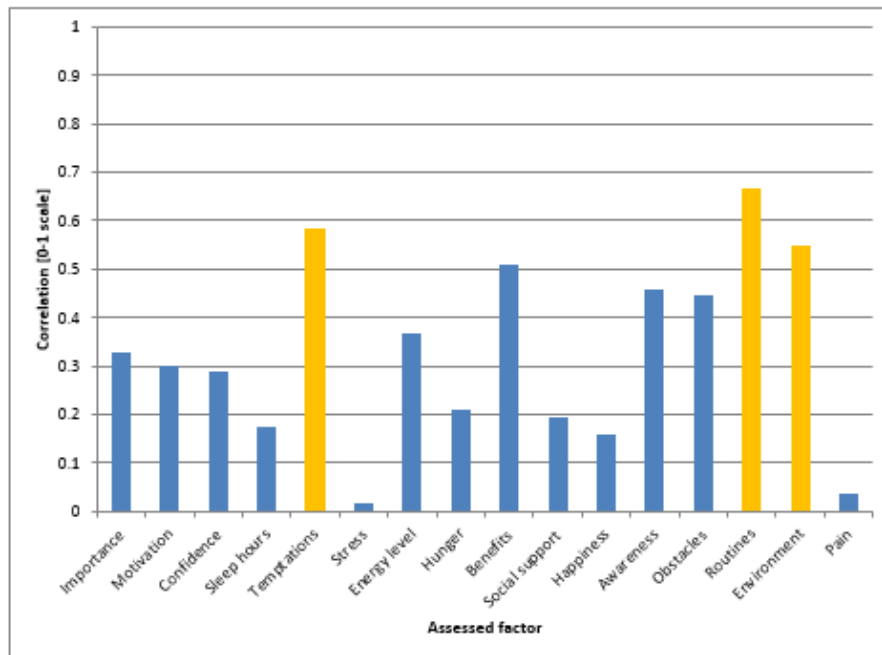
The graph below shows your daily ratings for 'following the plan'. The question you were asked every day was: "Did you follow your weight loss maintenance plan today?". You answered this question on 0 to 100 scale, (0 - I haven't followed my plan; 100 - I strictly followed my plan). Your average score was 56 out of 100 (with a minimum of 27 on the Christmas Day ☺ and maximum of 77).



We assessed which factors are the most important for you in order to follow your weight maintenance plan. In other words we looked into the relationships between each of the assessed factors and your reported score for 'following the plan'.

### Factors which are important for you to follow your weight maintenance plan

The graph below shows relationship between following the plan and other assessed factors. The higher the number (the closer to 1), the stronger is the relationship between following your plan and variables listed on the bottom of the graph.



For you personally three most important factors (factors which showed the strongest relationship with reported scores for following your weight maintenance plan) were:

- ❖ Routines
- ❖ Temptations
- ❖ Environment

During the study, we also have asked you to capture your experiences; to tell us a bit more about factors which influence your weight loss maintenance.

## Capturing your experiences

Here are some of the experiences which you have captured over the last two months. Your comments have been divided into themes:

### Obstacles

#### Routine disruptions

- *No proper cooking facilities - in middle of house extension.*

- *Stressful day regarding building work. Didn't do a proper shop this week so couldn't make good food choices. Pizza for dinner - no cooking facilities. Hopefully tomorrow will see me back on track.*



*Extra aches and pains! (02 December 2013 19:53) But worth it - our floor is starting to take shape - under-floor heating on its way. Cannot imagine feeling warm again after several weeks of being freezing cold.*

- *Had put weight on this weekend because of lack of cooking facilities and tiredness. Back to a warm working environment today and back on course (I hope)!*

#### Satisfaction with weight loss benefits

- *Again problems cooking. On a positive note wore my new jeans, size 12, for the first time tonight.*

- *Enjoyed work today. Good customer feedback. Retail therapy this p.m. Still cannot believe I can now get into much smaller clothes!*



### **Emotions**

Feeling down: - *Plumber didn't turn up - kitchen building works really getting me down.*

Feeling stressed: - *Busy, stressful week - have had a Chinese take-away tonight!!*

Feeling cold: - *Did not sleep so well last night. Felt very cold today. No heating at the hairdressers so three and a half hours of freezing cold conditions!*

Feeling tired: - *Kept to weight maintenance plan for most of day - Chinese takeaway for supper - too tired to cook, grouting kitchen floor all day!*

### **Temptations**

Dealing with temptations:

- *Busy day at work - had a head massage this pm and bought new boots. Felt hungry after evening meal had an extra pint of water and it did help.*

- *Craved chocolate today, ate four chocolates BUT that's ok as I will make better choices tomorrow.*

- *Had cream in my coffee - my treat turned out to be very sickly. Back to my semi-skimmed milk tomorrow!*

- *Good day food wise but have had some cheese and chocolate this evening.*

### **Positives**

- *Better day than yesterday 1lb weight gain reminded me to make more sensible food choices.*

- *Happy to be back at work and warmth! I'm feeling positive about getting back into making sensible food choices. I did a proper food shop after work tonight.*

- *Never thought I would be some ones inspiration! A work colleague from a former department has decided to embark on the same healthy eating programme as me! Better keep up the good work. Out tonight but I am driving and feel in control.*

- *Pleased to be back at work and into my routine. I've managed a 20 minute walk instead of a coffee break.*

## Overall summary

The things you have reported that are most closely related to your ability to follow your weight maintenance plan are: following your daily routines, number of temptations you experience and typicality of your environment. Overall your motivation to follow your weight maintenance plan is high compared to other things you want to do. You are motivated to follow your weight maintenance plan. And you appreciate the benefits of your recent weight loss.

Some threats to your ability to follow your plan are special occasions and social situations when you are not always in control of food options. You are less likely to follow your weight maintenance plan when you are down, stressed, cold or tired. That's when you report to crave comfort foods and sometimes make bad food choices. Your daily step count could increase slightly, especially on the weekends when you tend to be less active.





Thank you for taking part in the weight maintenance study. I hope you will enjoy your further study participation if you decide to continue on the study. If you have any questions regarding this report or regarding this study, please contact me: Dominika Kwasnicka [d.kwasnicka@ncl.ac.uk](mailto:d.kwasnicka@ncl.ac.uk).



## Appendix G Example report 6 months

# Weight Maintenance Study

## Personal Report – Final Summary



The Centre for Translational Research in Public Health

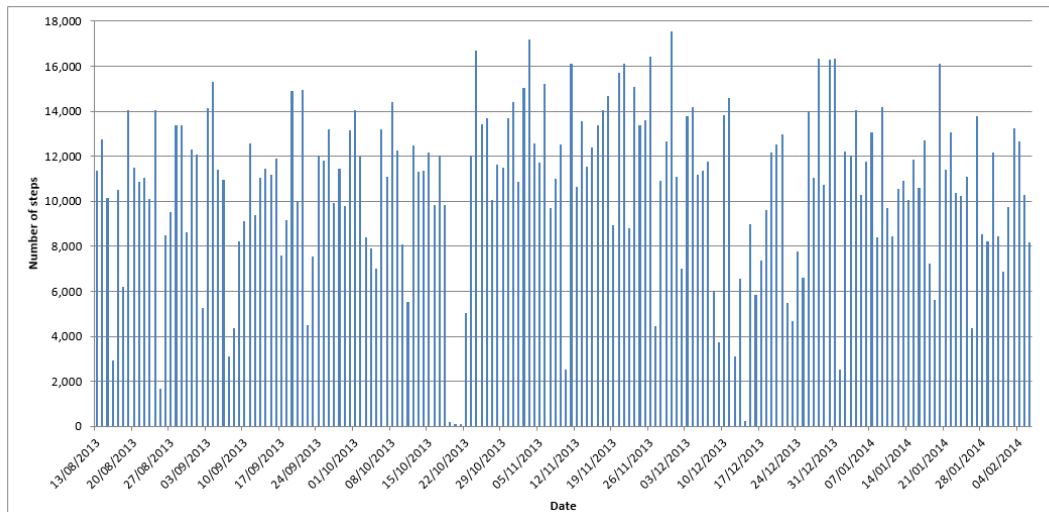
Time period covered in the report:  
13th August 2013 – 8th February 2014

*Success is only a starting point.  
Maintenance is a lifelong journey.*

### Your daily activity summary

#### Steps

This graph shows the number of steps you have taken each day:



### Steps

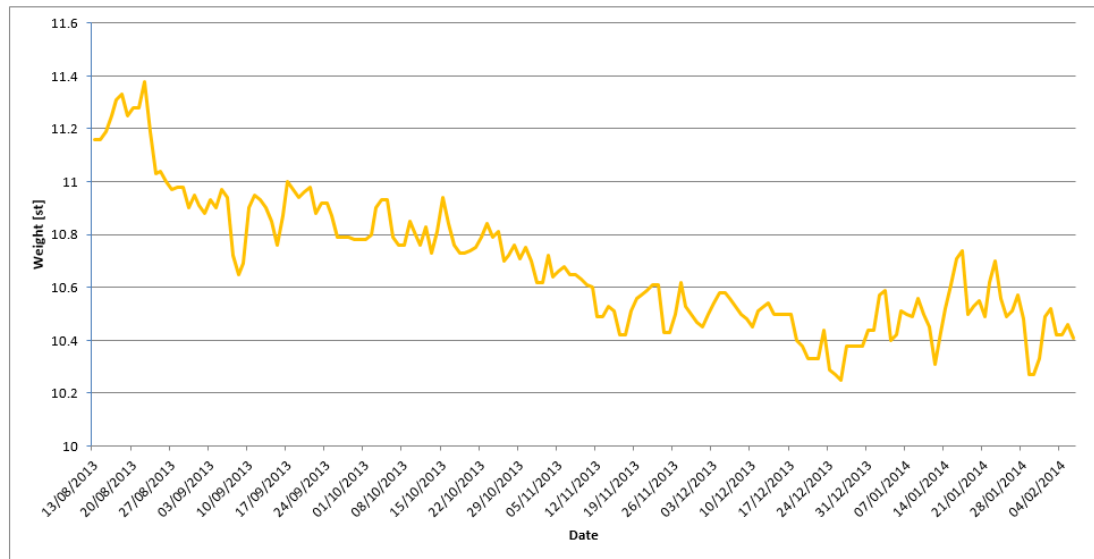
- ❖ On average you have taken **10,617 steps per day** (number will be higher if we added step count from days when you have not worn activity monitor). The recommended daily steps challenge is 10,000 steps per day<sup>1</sup>.
- ❖ Your average number of calories burned per day is **1,915** with **889** activity calories.
- ❖ Your self-reported **sleep time** is on average about **5 hours per night**. While sleep requirements vary from person to person, most healthy adults need between seven and a half to nine hours of sleep per night to function at their best. Here you can access more information provided by the NHS about common energy stealers:<http://www.nhs.uk/Livewell/tiredness-and-fatigue/Pages/causes-of-tiredness.aspx>



<sup>1</sup> NHS choices: <http://www.nhs.uk/Livewell/loseweight/Pages/10000stepschallenge.aspx>

### Your daily weighing summary

#### Weight



### Weight

- ❖ Your weight at the start was **11.16 st.**
- ❖ Your weight at 2 months was **10.74 st.**
- ❖ At 4 months it was **10.54 st.**
- ❖ And at 6 months it was **10.41 st.**
- ❖ This means that you successfully maintained your weight loss with some relatively small weight fluctuations.

Your weight is gradually decreasing.

- ❖ Your average body fat % is 39.7%; which is slightly outside a healthy range (for women, it is 14-31%).
- ❖ Your average BMI is **25.79**; you can always calculate it on 'NHS choices' website and check if you are in a healthy BMI range: <http://www.nhs.uk/Tools/Pages/Healthyweightcalculator.aspx>



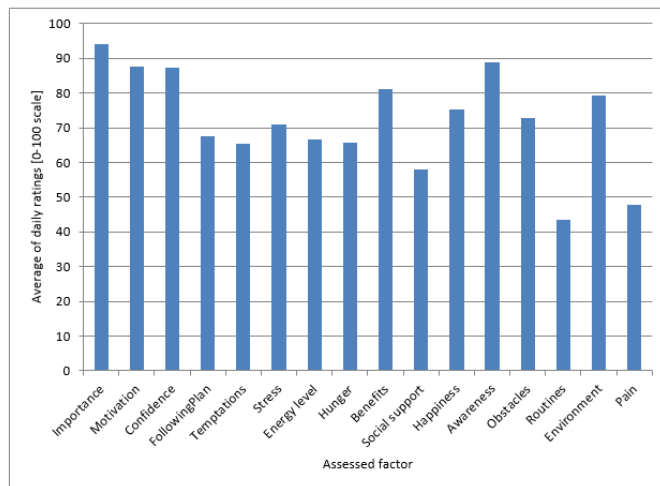
### Factors which influence your weight maintenance

#### Average score for each factor assessed

You have told us a lot about the factors that have influenced your weight maintenance over the last six months. The graph below summarises the average score for each factor.

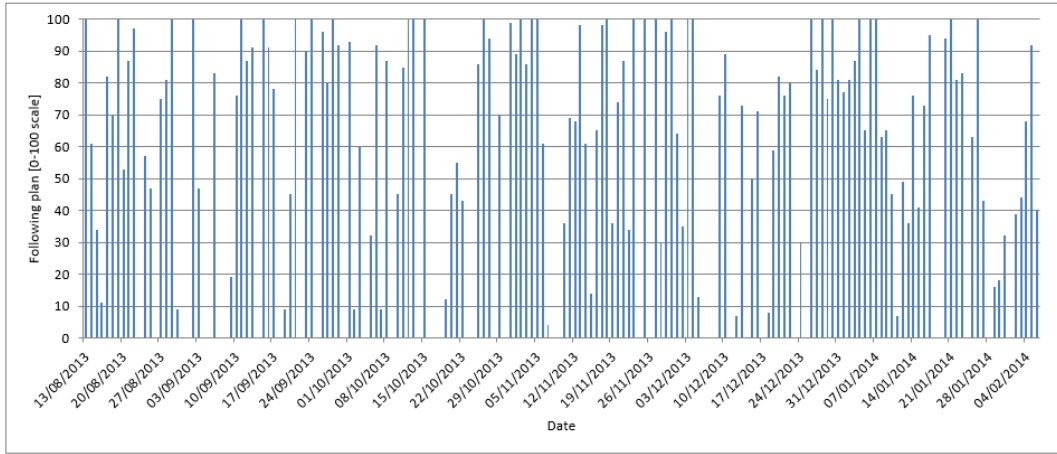
Factors on average rated higher were:

- ❖ Importance
- ❖ Awareness
- ❖ Motivation



### Following your weight maintenance plan

The graph below shows your daily ratings for 'following the plan'. The question you were asked every day was: "Did you follow your weight loss maintenance plan today?". You answered this question on 0 to 100 scale, (0 - I haven't followed my plan; 100 - I strictly followed my plan). Your average score was 68 out of 100.

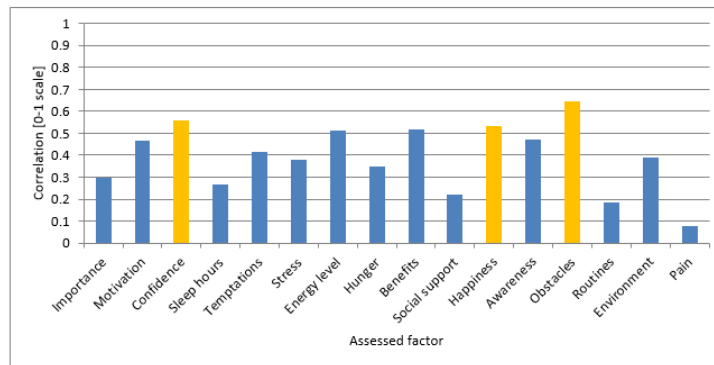


We assessed which factors are the most important for you to enable you to follow your weight maintenance plan. In other words we looked into the relationships between each of the assessed factors and your reported score for 'following the plan'.

### Factors which are important for you to follow your weight maintenance plan

The graph below shows relationship between following the plan and other assessed factors. The higher the number (the closer to 1), the stronger is the relationship between following your plan and variables listed on the bottom of the graph. For you personally, three most important factors (factors which showed the strongest relationship with reported scores for following your weight maintenance plan) were:

- ❖ Obstacles
- ❖ Confidence
- ❖ Happiness



During the study, we also have asked you to capture your experiences; to tell us a bit more about factors which influence your weight loss maintenance.

### **Capturing your experiences**

Here are some of the experiences which you have captured over the last two months. Your comments have been divided into themes:

#### **Motivation**

- I wonder if one me the morning questions should refer to how you feel after you have weighed yourself often this will have an impact on how motivated I am for the rest of the day.
- Felt so good today bought a new dress for Christmas, Peter was really supportive and said losing that weight was definitely paying off. Reminds me of the 60s. It never ceases to amaze me what a difference losing weight can make to your self-esteem :-).
- Pampered myself a little today had my eyebrows waxed and tinted and my eyelashes tinted also a hand massage which was lovely not something I would normally do. Definitely going to do that again. This is something I would never have thought of before losing my weight. Tried on some of my clothes I put to one side when I put on weight and could get into them so they are now in the charity bag, it's a great feeling.

#### **Self-regulation and coping with barriers**

- Over 14000 steps today, well done me. Have raised my steps daily goal to 11500.

- Enjoyed just relaxing today even though it's the holiday I'm trying to not over indulge even yesterday when family came over for nibble I did some healthy things.
- My motivation has been low over the last few days due to being off colour but starting to come back again.

#### **Psychological resources**

- It's amazing how losing a couple of pounds can make you feel so much more energetic.
- Played badminton which was great but painful can't wait to get back to the physio. This week my weight just seems to be creeping up (4lbs in 2 days) I'm becoming used to not getting too worried about it because I know it fluctuates.
- Not thinking too much about my diet at the moment others things on my mind, feeling very stressed and off work.

#### **Habits**

- It's amazing how many steps you do without realizing it. Tempted to up my daily allowance but maybe not.

#### **Environmental and social influences**

- Today I weighed less then I have for two and a half years yippee all the girls cheered me I felt as if I had achieved something.
- Had an appointment at my GP who is very happy with the weight I've lost. He is happy so I'm happy. Alex and I are supporting each other again, it's a real competition but fun
- As usual supported by Alex, we chat almost everyday but some days rather than chat we really do support each other. Again someone approached me and commented on my weight loss which is great. My weight is maintained between a couples of pounds now.

"Good job I don't do this very often" 26 October 2013 18:46



"Happy face lovely flowers from my team at work" 27 October 2013 19:17



"Another happy face" 27 October 2013 19:33



"My fab faux fur :-)" 01 December 2013 21:23



"Food Tree" Christmas tree made of food which I thought looked good

#### Overall summary

The things you have reported that are most closely related to your ability to follow your weight maintenance plan during the last 6 months were: obstacles, your level of confidence to follow your weight loss maintenance plan and your happiness levels. On average you've rated high the importance of your weight loss maintenance programme. You often reported that you were aware of your plan and very motivated to stick to it. Some threats to your ability to follow your plan were days when you were tired, when you experienced pain, nights when you don't get enough sleep. You said that friends and family played an important role in your weight management; they often gave you complements and motivated you. There were various sources of motivation to maintain you weight including higher self-esteem and satisfaction with weight loss outcomes. You reported that you sleep on average 5 hours per day which is below a recommended range.

A huge thank you for taking part in the weight maintenance study. I will be in touch to provide you with a further summary of the research. If you have any questions regarding this report or regarding this study, please contact me: Dominika Kwasnicka [d.kwasnicka@ncl.ac.uk](mailto:d.kwasnicka@ncl.ac.uk).



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## **Appendix H Interview manual - weight maintenance study**

### Semi-structured interview schedule

*Note: The interview schedule is developmental. The questions will be tailored to the specific answers for each interview and to specific data patterns. The focus of the questions may shift over the life of the study as analysis informs and develops direction of the study. This interview schedule is therefore a general topic guide for the one-to-one data-prompted interviews. Wording is only provisional.*

### **Introduction**

Dear <name> thank you for your study participation in the last two months and thank you for agreeing to take part in this interview. All data are confidential and no real names will appear in any reports about this study. Is it ok to record our session today?

The interview is divided into two sections: we will start focusing on your data that we collected over the past two months and we will end by asking about your own suggestions for best ways to successfully maintain the weight loss. Do you have any questions or concerns before we start our interview?

### **Part 1. Analysing your personal study data**

I would like to show you your study responses which we gathered during your study participation period. They have been analysed with a purpose to identify any behavioural patterns which may have occurred. We looked into your daily survey responses in relation to your daily activity and weight.

In each theme of the interview we will look at study responses and data. I will provide a summary of survey responses, point out any interesting data patterns and correlations. I will ask questions about the data patterns, data fluctuations and any interesting observations pointed out after analysing data. I will try to incorporate in the interview all the experience samples (comments, pictures) which fit into themes or which add beyond them.

## 1. Motives

We will start with motives for weight loss and for weight loss maintenance (motives are defined as reasons why people engage in a given behaviour)

### A. To lose weight

- Could you tell me what motivated you to lose weight initially? (Thoughts, attitudes, feelings)
- Was there any significant event in your life which motivated you to lose weight? (If so ask additional questions about the situation, people involved, feelings)

### B. To maintain weight

- Could you tell me what motivates you/keeps you going while you are maintaining your weight loss? (Prompt external as well as internal factors; ask which ones are perceived as more prominent)
- Would you say that satisfaction with outcomes is an important motivator for you? (Probe fitting to smaller size clothes, complements from others, being more physically active)
- Do you feel like you often compare efforts against benefits of your weight loss and decide if weight loss maintenance is worth pursuing? (E.g. effortful exercise, denying yourself treats versus maintaining weight loss).
- Do you often think of your long-term goal? (E.g. looking at appetising cake and thinking of your weight versus immediate pleasure) Do you set up yourself high and challenging goals or would you rather go one small step at the time?
- Would you say that you enjoy any activity which relates to maintaining your weight loss? (Feeling healthier, enjoying being active, engaging in sports, weight loss clubs; also 'feeling good about yourself')

- Would you say that your new weight maintenance routine is part of your identity/it defines you in a way? (Suggest being a healthy eater, being active, being a runner, swimmer, and 'weight maintainer')

## 2. Self-regulation

Now I would like to talk about your self-regulation (self-regulation is defined as ability to actively control behaviour; to override or inhibit behaviours, emotions or desires).

- Could you tell me about the diet which you follow? (Probe type of diet, meal times, calorie counting, limiting yourself or denying yourself treats) - Do you feel that you actively self-regulate what you eat? / Do you have to consciously remember to follow a healthy diet?
- Could you tell me a bit about your physical activity? (Probe activity types, intensity, duration) - Do you have to actively plan your physical activity? / Do you have to consciously remember to be physically active?
- How do you deal with temptations to break your diet, to overeat or to not be active?
- What do you do if it happens? (Ask about feelings, attitudes, and behaviours following the relapse)
- Do you have any strategies put in place to deal with trigger foods or situations in which you may not be successful in keeping your weight off?
- Are you confident / positive that you can overcome temptations? (Prompt perceived barriers, beliefs about ability to successfully overcome them, social support)

## 3. Resources

Now, let's talk about psychological and physical resources which influence your weight management (resources are assets that can be drawn on in order to engage in behaviour).

- Do you feel that your thoughts, feelings and emotions strongly influence your weight maintenance? (Prompt stress, happiness, and energy levels)
- Do you feel that the more you try to actively self-regulate your eating behaviour the more challenging it gets?
- Are there any situations or settings in which your weight maintenance becomes less important? (if so what happens then)
- Do you feel that your weight maintenance changes with age? (Prompt change in motives, shifting goals, facing different challenges)

#### 4. Habits

Let's move on and talk about your habits (habits are behavioural patterns, based on context-behaviour associations which are learned through context-dependent repetition).

- Are there any habits which you developed which help you maintain your weight loss? (Regular meals, exercise routine, weighting yourself) – How have you developed them?
- Are there any bad habits which you needed to overcome in order to keep your weight off? (Snacking, drinking wine, having a sedentary lifestyle) – Anything you had to unlearn?
- Does it happen sometimes that you come back to your previous bad habits? If so what do you do then? (Prompt coping strategies, staying positive)

#### 5. Environmental influences

Habits are often associated with certain environment. Let's talk about the context in which you are maintaining your weight loss (context is defined as the setting or conditions in which a particular activity is carried out).

- Thinking about your environment, are there any structural changes which you put in place that helped you maintain your weight loss? (Prompt buying different food, bringing healthy snacks to work, using smaller plates)

- Is the environment you are living in supportive towards your weight maintenance? (Think of your workplace, home, places where you spend your free time; discuss access to PA and healthy/unhealthy food options)

- Are people around you helping you to maintain your weight?

- Do you feel like you need any social support to maintain your weight loss? (If so who is important for you, who facilitates and who may hinder your weight loss maintenance?)

- Is it easy to maintain your weight living where you live, and having access to the resources you've got?

- Are there any social changes you can think off which influence your weight maintenance?

## **Part 2. Suggested ways to weight loss maintenance**

During last part of our interview, I would like to gather your opinions about how we can improve other people weight maintenance, about techniques which has been effective for you and which may also work for other people.

### *Behaviour change techniques*

- Was there any specific thing you've done or experienced that helped you keep the weight off which could be also effective for other people?

- What are the main barriers for you to maintain your weight which can also occur in other people lives? Do you have any good suggestions/advice how to overcome them?

*Environment and context changes*

- Are there any environment changes which people could introduce themselves to maintain their weight loss?

- What should be done locally to help people maintain healthy weight? (Prompt context changes, structures, e.g. healthy food options in restaurants, healthier snacks in vending machines)

- What should be done nationally to help people maintain healthy weight? (Prompt policy changes; national initiatives promoting healthy lifestyle)

**Close**

- Just before we finish, is there anything I should have asked you but didn't?

- And is there anything you would like to add to what you have already told me?

Thank you so much for all this information, it will all stay confidential and will be anonymised to present findings of the study.

## References

- Abraham, C., & Graham-Rowe, E. (2009). Are worksite interventions effective in increasing physical activity? A systematic review and meta-analysis. *Health Psychology Review, 3*(1), 108-144.
- Abraham, C., & Michie, S. (2008). A taxonomy of behavior change techniques used in interventions. *Health Psychology, 27*(3), 379-387. doi: 10.1037/0279-6133.27.3.379
- Adamson, S. J., Sellman, J. D., & Frampton, C. (2009). Patient predictors of alcohol treatment outcome: a systematic review. *Journal of substance abuse treatment, 36*(1), 75-86.
- Ajzen, I. (1985). *From intentions to actions: A theory of planned behavior*: Springer.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211. doi: 10.1016/0749-5978(91)90020-t
- Albarracin, D., Gillette, J. C., Earl, A. N., Glasman, L. R., Durantini, M. R., & Ho, M. H. (2005). A test of major assumptions about behavior change: A comprehensive look at the effects of passive and active HIV-prevention interventions since the beginning of the epidemic. *Psychological Bulletin, 131*(6), 856-897. doi: 10.1037/0033-2909.131.6.856
- Alfonzo, M. A. (2005). To walk or not to walk? The hierarchy of walking needs. *Environment and Behavior, 37*(6), 808-836.
- Amireault, S., Godin, G., & Vézina-Im, L.-A. (2013). Determinants of physical activity maintenance: a systematic review and meta-analyses. *Health Psychology Review, 7*(1), 55-91.
- Antonovsky, A. (1996). The salutogenic model as a theory to guide health promotion. *Health promotion international, 11*(1), 11-18.
- Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology, 40*(4), 471-499.
- Årsand, E., Frøisland, D. H., Skrøvseth, S. O., Chomutare, T., Tatara, N., Hartvigsen, G., & Tufano, J. T. (2012). Mobile health applications to assist patients with diabetes: lessons learned and design implications. *Journal of Diabetes Science and Technology, 6*(5), 1197-1206.
- Arterburn, D. E., Westbrook, E. O., Bogart, T. A., Sepucha, K. R., Bock, S. N., & Weppner, W. G. (2011). Randomized Trial of a Video-Based Patient Decision Aid for Bariatric Surgery. *Obesity, 19*(8), 1669-1675.



- Avenell, A., Broom, J., Brown, T. J., Poobalan, A., Aucott, L., Stearns, S. C., . . . Grant, A. M. (2004). Systematic review of the long-term effects and economic consequences of treatments for obesity and implications for health improvement.
- Bagnoli, A. (2009). Beyond the standard interview: The use of graphic elicitation and arts-based methods. *Qualitative Research, 9*(5), 547-570.
- Bagozzi, R. P. (1992). The self-regulation of attitudes, intentions and behavior. *Social Psychology Quarterly, 55*(2), 178-204.
- Balleine, B. W., & Killcross, S. (2006). Pavlovian–instrumental transfer. *Trends in Neurosciences, 29*(5), 272-279.
- Baltes, P. B. (1997). On the incomplete architecture of human ontogeny - Selection, optimization, and compensation as foundation of developmental theory. *American Psychologist, 52*(4), 366-380. doi: 10.1037//0003-066x.52.4.366
- Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191.
- Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall.
- Bandura, A., & Cervone, D. (1983). Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. *Journal of Personality and Social Psychology, 45*(5), 1017-1028. doi: 10.1037//0022-3514.45.5.1017
- Bandura, A., & McClelland, D. C. (1977). *Social learning theory*.
- Barnes, A. S., Goodrick, G. K., Pavlik, V., Markesino, J., Laws, D. Y., & Taylor, W. C. (2007). Weight loss maintenance in African–American women: Focus group results and questionnaire development. *Journal of general internal medicine, 22*(7), 915-922.
- Bartley, M. (2004). *Health inequality: An introduction to theories, concepts and methods*.
- Barua, D., Kay, J., & Paris, C. (2013). Viewing and controlling personal sensor data: what do users want? *Persuasive Technology* (pp. 15-26): Springer.
- Baumeister, R. F. (2002). Yielding to Temptation: Self-Control Failure, Impulsive Purchasing, and Consumer Behavior. *Journal of Consumer Research, 28*(4), 670-676.

- Baumeister, R. F. (2003). Ego depletion and self-regulation failure: A resource model of self-control. *Alcoholism-Clinical and Experimental Research*, 27(2), 281-284. doi: 10.1097/01.alc.0000060879.61384.a4
- Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology*, 74(5), 1252-1265. doi: 10.1037/0022-3514.74.5.1252
- Baumeister, R. F., & Heatherton, T. F. (1996). Self-regulation failure: An overview. *Psychological Inquiry*, 7(1), 1-15. doi: 10.1207/s15327965pli0701\_1
- Baumeister, R. F., Heatherton, T. F., & Tice, D. M. (1994). *Losing control: How and why people fail at self-regulation*. San Diego: Academic Press.
- Baumeister, R. F., Muraven, M., & Tice, D. M. (2000). Ego depletion: A resource model of volition, self-regulation, and controlled processing. *Social Cognition*, 18(2), 130-150. doi: 10.1521/soco.2000.18.2.130
- Beccuti, G., & Pannain, S. (2011). Sleep and obesity. *Current opinion in clinical nutrition and metabolic care*, 14(4), 402.
- Becker, G. S., & Murphy, K. M. (1988). A theory of rational addiction. *The Journal of Political Economy*, 675-700.
- Bélanger-Gravel, A., Godin, G., & Amireault, S. (2013). A meta-analytic review of the effect of implementation intentions on physical activity. *Health Psychology Review*, 7(1), 23-54.
- Bell, S. E. (2002). Photo Images: Jo Spence's Narratives of Living with Illness. *Health*, 6(1), 5-30. doi: 10.1177/136345930200600102
- Bellg, A. J. (2003). Maintenance of health behavior change in preventive cardiology - Internalization and self-regulation of new behaviors. *Behavior Modification*, 27(1), 103-131. doi: 10.1177/0145445502238696
- Bem, D. J. (1967). Self-perception: An alternative interpretation of cognitive dissonance phenomena. *Psychological Review*, 74(3), 183.
- Bem, D. J. (1972). Self-perception theory. *Advances in experimental social psychology*, 6, 1-62.
- Bem, S., & Looren de Jong, H. (1997). *Theoretical Issues in Psychology* (1st ed.). London: SAGE Publications Ltd
- Berkowitz, A. D. (2003). Applications of social norms theory to other health and social justice issues. *The social norms approach to preventing school and*

*college age substance abuse: A handbook for educators, counselors, and clinicians, 259-279.*

- Berkowitz, A. D. (2004). The social norms approach: Theory, research and annotated bibliography. *Higher Education Center for Alcohol and Other Drug Abuse and Violence Prevention. US Department of Education.*
- Bissell, S., Manderson, L., & Allotey, P. (2000). In focus: Film, focus groups and working children in Bangladesh. *Visual Anthropology, 13*(2), 169-183.
- Blackburn, G. (1995). Effect of degree of weight loss on health benefits. *Obesity research, 3*(S2), 211s-216s.
- Boekaerts, M. (1997). Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers, and students. *Learning and instruction, 7*(2), 161-186.
- Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual review of psychology, 54*(1), 579-616.
- Bouton, M. E. (2000). A learning theory perspective on lapse, relapse, and the maintenance of behavior change. *Health Psychology, 19*(1), 57-63. doi: 10.1037/0278-6133.19.Suppl1.57
- Bowen, M. (1966). The use of family theory in clinical practice. *Comprehensive Psychiatry, 7*(5), 345-374.
- Bracken, B. A. (1996). *Handbook of self-concept: Developmental, social, and clinical considerations*: John Wiley & Sons.
- Bradley, E. H., Curry, L. A., & Devers, K. J. (2007). Qualitative data analysis for health services research: developing taxonomy, themes, and theory. *Health services research, 42*(4), 1758-1772.
- Bravata, D. M., Smith-Spangler, C., Sundaram, V., Gienger, A. L., Lin, N., Lewis, R., . . . Sirard, J. R. (2007). Using pedometers to increase physical activity and improve health: a systematic review. *JAMA, 298*(19), 2296-2304.
- Breton, E. R., Fuemmeler, B. F., & Abrams, L. C. (2011). Weight loss—there is an app for that! But does it adhere to evidence-informed practices? *Translational Behavioral Medicine, 1*(4), 523-529.
- Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American Psychologist, 32*, 513-531.

- Bronfenbrenner, U. (1986). Ecology of the Family as a Context for Human Development: Research Perspectives. *Developmental Psychology*, 22(6), 723-742.
- Brown, C., Costley, C., Friend, L., & Varey, R. (2010). Capturing their dream: Video diaries and minority consumers. *Consumption Markets & Culture*, 13(4), 419-436. doi: Doi 10.1080/10253866.2010.502420
- Brown, I., & Gould, J. (2011). Decisions about weight management: a synthesis of qualitative studies of obesity. *Clinical Obesity*, 1(2-3), 99-109.
- Brown, T., Kelly, S., & Summerbell, C. (2007). Prevention of obesity: a review of interventions. *Obesity Reviews*, 8(s1), 127-130.
- Burke, L. E., Wang, J., & Sevick, M. A. (2011). Self-monitoring in weight loss: a systematic review of the literature. *Journal of the American Dietetic Association*, 111(1), 92-102.
- Burnet, D., Plaut, A., Courtney, R., & Chin, M. H. (2002). A practical model for preventing type 2 diabetes in minority youth. *The Diabetes Educator*, 28(5), 779-795.
- Butland, B., Jebb, S., Kopelman, P., McPherson, K., Thomas, S., Mardell, J., & Parry, V. (2007). Foresight. Tackling obesity: future choices. Project report. *Foresight. Tackling obesity: future choices. Project report.*
- Butryn, M. L., Phelan, S., Hill, J. O., & Wing, R. R. (2007). Consistent Self-monitoring of Weight: A Key Component of Successful Weight Loss Maintenance. *Obesity*, 15(12), 3091-3096.
- Byrne, S., Cooper, Z., & Fairburn, C. (2003). Weight maintenance and relapse in obesity: a qualitative study. *International Journal of Obesity*, 27(8), 955-962.
- Caballero, B. (2007). The global epidemic of obesity: an overview. *Epidemiologic reviews*, 29(1), 1-5.
- Cane, J., O'Connor, D., & Michie, S. (2012). Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation Science*, 7. doi: 10.1186/1748-5908-7-37
- Carels, R. A., Douglass, O. M., Cacciapaglia, H. M., & O'Brien, W. H. (2004). An ecological momentary assessment of relapse crises in dieting. *Journal of Consulting and Clinical Psychology*, 72(2), 341.
- Carels, R. A., Hoffman, J., Collins, A., Raber, A. C., Cacciapaglia, H., & O'Brien, W. H. (2002). Ecological momentary assessment of temptation and lapse in dieting. *Eating Behaviors*, 2(4), 307-321.

- Carpenter, M. J., Jardin, B. F., Burris, J. L., Mathew, A. R., Schnoll, R. A., Rigotti, N. A., & Cummings, K. M. (2013). Clinical strategies to enhance the efficacy of nicotine replacement therapy for smoking cessation: a review of the literature. *Drugs*, 73(5), 407-426.
- Carver, C. S., & Scheier, M. F. (1982). Control theory: A useful conceptual framework for personality-social, clinical, and health psychology. *Psychological Bulletin*, 92, 111-135.
- Casazza, K., Fontaine, K. R., Astrup, A., Birch, L. L., Brown, A. W., Bohan Brown, M. M., . . . Heymsfield, S. B. (2013). Myths, presumptions, and facts about obesity. *New England Journal of Medicine*, 368(5), 446-454.
- Catania, J. A., Kegeles, S. M., & Coates, T. J. (1990). Towards an understanding of risk behavior: An AIDS risk reduction model (ARRM). *Health Education & Behavior*, 17(1), 53-72.
- Cecchini, M., Sassi, F., Lauer, J. A., Lee, Y. Y., Guajardo-Barron, V., & Chisholm, D. (2010). Tackling of unhealthy diets, physical inactivity, and obesity: health effects and cost-effectiveness. *The Lancet*, 376(9754), 1775-1784.
- Change4Life. (2015). About Change4Life: Department of Health.
- Chou, C., & Lee, K. (2002). Improving residents' interviewing skills by group videotape review. *Academic Medicine*, 77(7), 744.
- Chou, W.-y. S., Prestin, A., & Kunath, S. (2014). Obesity in social media: a mixed methods analysis. *Translational Behavioral Medicine*, 1-10.
- Christensen, T. C., Barrett, L. F., Bliss-Moreau, E., Lebo, K., & Kaschub, C. (2003). A practical guide to experience-sampling procedures. *Journal of Happiness Studies*, 4(1), 53-78.
- Christopherson, K. M. (2007). The positive and negative implications of anonymity in Internet social interactions: "On the Internet, nobody knows you're a dog". *Computers in Human Behavior*, 23(6), 3038-3056.
- Clark-Ibanez, M. (2004). Framing the social world with photo-elicitation interviews. *American behavioral scientist*, 47(12), 1507-1527.
- Cohen, L. L., Feinstein, A., Masuda, A., & Vowles, K. E. (2014). Single-case research design in pediatric psychology: Considerations regarding data analysis. *Journal of pediatric psychology*, 39(2), 124-137.
- Coleman, T., Murphy, E., & Cheater, F. (2000). Factors influencing discussion of smoking between general practitioners and patients who smoke: a qualitative study. *The British Journal of General Practice*, 50(452), 207.

- Collins, R. L., & Lapp, W. M. (1992). The temptation and restraint inventory for measuring drinking restraint. *British Journal of Addiction, 87*(4), 625-633.
- Cooper, C. M., & Yarbrough, S. P. (2010). Tell Me-Show Me: Using Combined Focus Group and Photovoice Methods to Gain Understanding of Health Issues in Rural Guatemala. *Qualitative health research, 20*(5), 644-653. doi: Doi 10.1177/1049732310361894
- Corbit, L. H., & Balleine, B. W. (2005). Double dissociation of basolateral and central amygdala lesions on the general and outcome-specific forms of pavlovian-instrumental transfer. *The Journal of neuroscience, 25*(4), 962-970.
- Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2008). Developing and evaluating complex interventions: the new Medical Research Council guidance. *BMJ, 337*.
- Crawford, D., Jeffery, R. W., & French, S. A. (2000). Can anyone successfully control their weight? Findings of a three year community-based study of men and women. *International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity, 24*(9), 1107-1110.
- Crawford, R., & Glover, L. (2012). The impact of pre-treatment weight-loss expectations on weight loss, weight regain, and attrition in people who are overweight and obese: A systematic review of the literature. *British journal of health psychology, 17*(3), 609-630.
- Crilly, N., Blackwell, A. F., & Clarkson, J. P. (2006). Graphic elicitation: using research diagrams as interview stimuli. *Qualitative Research, 6*, 341-366. doi: 10.1177/1468794106065007
- Csikszentmihalyi, M., & Larson, R. (1987). Validity and reliability of the experience-sampling method. *The Journal of nervous and mental disease, 175*(9), 526-536.
- Cummings, T., & Worley, C. (2014). *Organization development and change*: Cengage Learning.
- Cuntz, U., Leibbrand, R., Ehrig, C., Shaw, R., & Fichter, M. M. (2001). Predictors of post-treatment weight reduction after in-patient behavioral therapy. *International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity, 25*, S99-S101.
- Curioni, C. C., & Lourenco, P. M. (2005). Long-term weight loss after diet and exercise: a systematic review. *International Journal of Obesity, 29*(10), 1168-1174.

- Cussler, E. C., Teixeira, P. J., Going, S. B., Houtkooper, L. B., Metcalfe, L. L., Blew, R. M., . . . Lohman, T. G. (2008). Maintenance of Weight Loss in Overweight Middle-aged Women Through the Internet. *Obesity, 16*(5), 1052-1060.
- Dale, K. S., McAuley, K. A., Taylor, R. W., Williams, S. M., Farmer, V. L., Hansen, P., . . . Mann, J. I. (2009). Determining optimal approaches for weight maintenance: a randomized controlled trial. *Canadian Medical Association Journal, 180*(10), E39-E46.
- Davidson, K. W., Peacock, J., Kronish, I. M., & Edmondson, D. (2014). Personalizing Behavioral Interventions Through Single-Patient (N-of-1) Trials. *Social and personality psychology compass, 8*(8), 408-421.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly, 3*19-340.
- Davis, R., Campbell, R., Hildon, Z., Hobbs, L., & Michie, S. (2014). Theories of behaviour and behaviour change across the social and behavioural sciences: a scoping review. *Health Psychology Review*(ahead-of-print), 1-22.
- De Bruin, M., Hosters, H. J., Van Den Borne, H. W., Kok, G., & Prins, J. M. (2005). Theory- and Evidence-Based Intervention to Improve Adherence to Antiretroviral Therapy Among HIV-Infected Patients in The Netherlands: A Pilot Study. *AIDS PATIENT CARE and STDs, 19*(6), 384-394.
- De Vries, H., Mudde, A., Dijkstra, A., Norman, P., Abraham, C., & Conner, M. (2000). The attitude-social influence-efficacy model applied to the prediction of motivational transitions in the process of smoking cessation. *Understanding and Changing Health Behavior: From Health Beliefs to Self Regulation. Amsterdam, The Netherlands: Harwood Academic, 165-187.*
- De Vries, H. d., Mesters, I., Steeg, H. v. d., & Honing, C. (2005). The general public's information needs and perceptions regarding hereditary cancer: an application of the Integrated Change Model. *Patient education and counseling, 56*(2), 154-165.
- de Wit, S., & Dickinson, A. (2009). Associative theories of goal-directed behaviour: a case for animal-human translational models. *Psychological Research-Psychologische Forschung, 73*(4), 463-476. doi: 10.1007/s00426-009-0230-6
- Deci, E. L., & Ryan, R. M. (2000). The "what" and the "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*, 227-268.
- Deci, E. L., & Ryan, R. M. (2002). *Handbook of self-determination research*: University Rochester Press.

- Deci, E. L., & Ryan, R. M. (2010). *Self-Determination*: Wiley Online Library.
- Department of Health. (2011a). *Healthy Lives, Healthy People: A call to action on obesity in England*. London: Retrieved from <https://www.gov.uk/government/publications/healthy-lives-healthy-people-a-call-to-action-on-obesity-in-england>.
- Department of Health. (2011b). *Obesity*. Retrieved from <http://www.dh.gov.uk/health/category/policy-areas/public-health/obesity-healthy-living/>.
- Department of Health. (2011c). *UK physical activity guidelines*. Retrieved from <https://www.gov.uk/government/publications/uk-physical-activity-guidelines>.
- Department of Health. (2013a). Final design of consistent nutritional labelling system given green light [Press release]. Retrieved from <https://www.gov.uk/government/news/final-design-of-consistent-nutritional-labelling-system-given-green-light>
- Department of Health. (2013b). *Public Health Responsibility Deal* Retrieved from <https://responsibilitydeal.dh.gov.uk/>.
- Department of Health. (2013c). *Reducing obesity and improving diet*. Retrieved from <https://www.gov.uk/government/policies/reducing-obesity-and-improving-diet>.
- Department of Health. (2014). *Reducing obesity and improving diet*. England: Retrieved from <https://www.gov.uk/government/policies/reducing-obesity-and-improving-diet>.
- DePue, J. D., Clark, M. M., Ruggiero, L., Medeiros, M. L., & Pera, V. (1995). Maintenance of weight loss: a needs assessment. *Obesity research*, 3(3), 241-248.
- Dillard, J. P., & Pfau, M. W. (2002). *The persuasion handbook: Developments in theory and practice*: Sage Publications.
- DiMatteo, M. R., Haskard-Zolnierrek, K. B., & Martin, L. R. (2012). Improving patient adherence: a three-factor model to guide practice. *Health Psychology Review*, 6(1), 74-91.
- Direito, A., Dale, L. P., Shields, E., Dobson, R., Whittaker, R., & Maddison, R. (2014). Do physical activity and dietary smartphone applications incorporate evidence-based behaviour change techniques? *BMC public health*, 14(1), 646.



- Dobkin, B. H., & Dorsch, A. (2011). The promise of mHealth daily activity monitoring and outcome assessments by wearable sensors. *Neurorehabilitation and Neural Repair*, 25(9), 788-798.
- Dombrowski, S. U., Avenell, A., & Sniehotta, F. F. (2010). Behavioural Interventions for Obese Adults with Additional Risk Factors for Morbidity: Systematic Review of Effects on Behaviour, Weight and Disease Risk Factors. *Obesity Facts*, 3(6), 377-396. doi: 10.1159/000323076
- Dombrowski, S. U., Knittle, K., Avenell, A., Araújo-Soares, V., & Sniehotta, F. F. (2014). Long term maintenance of weight loss with non-surgical interventions in obese adults: systematic review and meta-analyses of randomised controlled trials. *BMJ*, 1-12. doi: 10.1136/bmj.g2646
- Douketis, J. D., Macie, C., Thabane, L., & Williamson, D. F. (2005). Systematic review of long-term weight loss studies in obese adults: clinical significance and applicability to clinical practice. *International Journal of Obesity*, 29(10), 1153-1167.
- Dresler-Hawke, E., & Veer, E. (2006). Making healthy eating messages more effective: combining integrated marketing communication with the behaviour ecological model. *International Journal of Consumer Studies*, 30(4), 318-326.
- Drew, S. E., Duncan, R. E., & Sawyer, S. M. (2010). Visual storytelling: a beneficial but challenging method for health research with young people. *Qualitative health research*, 20(12), 1677-1688.
- Duan, N., Kravitz, R. L., & Schmid, C. H. (2013). Single-patient (n-of-1) trials: a pragmatic clinical decision methodology for patient-centered comparative effectiveness research. *Journal of clinical epidemiology*, 66(8), S21-S28.
- Elfhag, K., & Rössner, S. (2005). Who succeeds in maintaining weight loss? A conceptual review of factors associated with weight loss maintenance and weight regain. *Obesity Reviews*, 6(1), 67-85.
- Epiphaniou, E., & Ogden, J. (2010). Successful Weight Loss Maintenance and a Shift in Identity From Restriction to a New Liberated Self. *Journal of Health Psychology*, 15(6), 887-896. doi: 10.1177/1359105309358115
- Ewart, C. K. (1991). Social action theory for a public health psychology. *American Psychologist*, 46(9), 931.
- Eysenbach, G., & Consort-Ehealth Group. (2011). CONSORT-EHEALTH: improving and standardizing evaluation reports of Web-based and mobile health interventions. *Journal of medical Internet research*, 13(4).

- Finch, E. A., Linde, J. A., Jeffery, R. W., Rothman, A. J., King, C. M., & Levy, R. L. (2005). The effects of outcome expectations and satisfaction on weight loss and maintenance: correlational and experimental analyses—a randomized trial. *Health Psychology, 24*(6), 608.
- Finucane, M. M., Stevens, G. A., Cowan, M. J., Danaei, G., Lin, J. K., Paciorek, C. J., . . . Bahalim, A. N. (2011). National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9·1 million participants. *The Lancet, 377*(9765), 557-567.
- Fishbein, M. (2000). The role of theory in HIV prevention. *AIDS care, 12*(3), 273-278.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*.
- Fishburn, P. C. (1968). Utility theory. *Management science, 14*(5), 335-378.
- Fisher, J. D., Fisher, W. A., Williams, S. S., & Malloy, T. E. (1994). Empirical tests of an information-motivation-behavioral skills model of AIDS-preventive behavior with gay men and heterosexual university students. *Health Psychology, 13*(3), 238.
- Fjeldsoe, B., Neuhaus, M., Winkler, E., & Eakin, E. (2011). Systematic review of maintenance of behavior change following physical activity and dietary interventions. *Health Psychology, 30*(1), 99.
- Flay, B. R., d'Avernas, J. R., Best, J. A., Kersell, M. W., & Ryan, K. B. (1983). Cigarette smoking: Why young people do it and ways of preventing it. *Pediatric and adolescent behavioral medicine, 10*, 132-183.
- Flay, B. R., DiTecco, D., & Schlegel, R. P. (1980). Mass media in health promotion: An analysis using an extended information-processing model. *Health Education & Behavior, 7*(2), 127-147.
- Fletcher, J. M., Marks, A. D. G., & Hine, D. W. (2011). Working memory capacity and cognitive styles in decision-making. *Personality and Individual Differences, 50*(7), 1136-1141. doi: 10.1016/j.paid.2011.02.002
- Fogelholm, M., & Kukkonen-Harjula, K. (2000). Does physical activity prevent weight gain—a systematic review. *Obesity Reviews, 1*(2), 95-111.
- Forgas, J. P. (1995). Mood and judgment: the affect infusion model (AIM). *Psychological Bulletin, 117*(1), 39.
- Forgas, J. P. (2001). The Affect Infusion Model (AIM): An integrative theory of mood effects on cognition and judgments.

- Franklin, R. D., Allison, D. B., & Gorman, B. S. (2014). *Design and analysis of single-case research*: Psychology Press.
- Franz, M. J., VanWormer, J. J., Crain, A. L., Boucher, J. L., Histon, T., Caplan, W., . . . Pronk, N. P. (2007). Weight-loss outcomes: a systematic review and meta-analysis of weight-loss clinical trials with a minimum 1-year follow-up. *Journal of the American Dietetic Association, 107*(10), 1755-1767.
- Friese, M., Hofmann, W., & Wanke, M. (2008). When impulses take over: Moderated predictive validity of explicit and implicit attitude measures in predicting food choice and consumption behaviour. *British Journal of Social Psychology, 47*, 397-419. doi: 10.1348/014466607x241540
- Gaesser, G. A. (2013). *Big fat lies: The truth about your weight and your health*. Carlsbad: Gurze Books.
- Gao, G., Burke, N., Somkin, C. P., & Pasick, R. (2009). Considering culture in physician—patient communication during colorectal cancer screening. *Qualitative health research, 19*(6), 778-789.
- Gardner, B., de Bruijn, G.-J., & Lally, P. (2011). A systematic review and meta-analysis of applications of the self-report habit index to nutrition and physical activity behaviours. *Annals of Behavioral Medicine, 42*(2), 174-187.
- Garip, G., & Yardley, L. (2011). A synthesis of qualitative research on overweight and obese people's views and experiences of weight management. *Clinical Obesity, 1*(2-3), 110-126.
- Gatersleben, B., & Vlek, C. (1998). Household consumption, quality of life, and environmental impacts: A psychological perspective and empirical study. *Green households, 141-183*.
- Gebhardt, W. A. (1997). *Health Behaviour Goal Model: Towards a Theoretical Framework for Health Behaviour Change*. Leiden Leiden University Press.
- Gerard Sister, A. (1959). The interview; a conversation with a purpose. *Hospital progress, 40*(7), 126-130.
- Gerrard, M., Gibbons, F. X., Houlihan, A. E., Stock, M. L., & Pomery, E. A. (2008). A dual-process approach to health risk decision making: The prototype willingness model. *Developmental Review, 28*(1), 29-61.
- Gibson, B. E., Mistry, B., Smith, B., Yoshida, K. K., Abbott, D., Lindsay, S., & Hamdani, Y. (2013). The Integrated Use of Audio Diaries, Photography, and Interviews in Research with Disabled Young Men. *International Journal of Qualitative Methods, 12*, 382-402.

- Gilmore, L. A., Duhé, A. F., Frost, E. A., & Redman, L. M. (2014). The Technology Boom A New Era in Obesity Management. *Journal of Diabetes Science and Technology*, 1932296814525189.
- Glasgow, R. E., Vogt, T. M., & Boles, S. M. (1999). Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *American Journal of Public Health*, 89(9), 1322-1327.
- Gollwitzer, P. M. (1999). Implementation intentions - Strong effects of simple plans. *American Psychologist*, 54(7), 493-503. doi: 10.1037/0003-066x.54.7.493
- Gonzalez, G. M. (1989). An integrated theoretical model for alcohol and other drug abuse prevention on the college campus. *Journal of College Student Development*.
- Gorin, A. A., Pinto, A. M., Tate, D. F., Raynor, H. A., Fava, J. L., & Wing, R. R. (2007). Failure to meet weight loss expectations does not impact maintenance in successful weight losers. *Obesity*, 15(12), 3086-3090.
- Gortmaker, S. L., Swinburn, B. A., Levy, D., Carter, R., Mabry, P. L., Finegood, D. T., . . . Moodie, M. L. (2011). Changing the future of obesity: science, policy, and action. *The Lancet*, 378(9793), 838-847.
- Graybiel, A. M. (1995). Building action repertoires: Memory and learning functions of the basal ganglia. *Current Opinion in Neurobiology*, 5(6), 733-741. doi: 10.1016/0959-4388(95)80100-6
- Graybiel, A. M. (2005). The basal ganglia: learning new tricks and loving it. *Current Opinion in Neurobiology*, 15(6), 638-644. doi: 10.1016/j.conb.2005.10.006
- Greaves, C., Reddy, P., & Sheppard, K. (2010). Supporting Behaviour Change for Diabetes Prevention. In P. Schwarz, P. Reddy, C. Greaves, J. Dunbar, & S. J. (Eds.), *Diabetes prevention in practice* (pp. 19-29). Dresden: Tumaini Institute for Prevention Management.
- Greaves, C., Reddy, P., & Sheppard, K. (2012). Supporting behaviour change for diabetes prevention. *Diabetes prevention in practice*, 19-29.
- Grossman, M. (1972). On the concept of health capital and the demand for health. *The Journal of Political Economy*, 223-255.
- Guerra, C. E., Katrina Armstrong Md, M., & Brown, J. S. (2007). Barriers of and facilitators to physician recommendation of colorectal cancer screening. *Journal of general internal medicine*, 22(12), 1681-1688.

- Gunn, R. L., Finn, P. R., Endres, M. J., Gerst, K. R., & Spinola, S. (2013). Dimensions of disinhibited personality and their relation with alcohol use and problems. *Addictive Behaviors, 38*(7), 2352-2360.
- Haedt-Matt, A. A., & Keel, P. K. (2011). Revisiting the affect regulation model of binge eating: A meta-analysis of studies using ecological momentary assessment. *Psychological Bulletin, 137*(4), 660.
- Hagger, M. S., Chatzisarantis, N. L. D., Culverhouse, T., & Biddle, S. J. H. (2003). The processes by which perceived autonomy support in physical education promotes leisure-time physical activity intentions and behavior: a trans-contextual model. *Journal of Educational Psychology, 95*(4), 784.
- Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2009). The strength model of self-regulation failure and health-related behaviour. *Health Psychology Review, 3*(2), 208-238.
- Hall, J., Parkinson, J. A., Connor, T. M., Dickinson, A., & Everitt, B. J. (2001). Involvement of the central nucleus of the amygdala and nucleus accumbens core in mediating Pavlovian influences on instrumental behaviour. *European Journal of Neuroscience, 13*, 1984-1992.
- Hall, P. A. (2013). Temporal Self-Regulation Theory *Encyclopedia of Behavioral Medicine* (pp. 1960-1963): Springer.
- Hall, P. A., & Fong, G. T. (2007). Temporal self-regulation theory: A model for individual health behavior. *Health Psychology Review, 1*(1), 6-52.
- Hall, P. A., Fong, G. T., Epp, L. J., & Elias, L. J. (2008). Executive function moderates the intention-behavior link for physical activity and dietary behavior. *Psychology & Health, 23*(3), 309-326. doi: 10.1080/14768320701212099
- Hankinson, A. L., Daviglius, M. L., Bouchard, C., Carnethon, M., Lewis, C. E., Schreiner, P. J., . . . Sidney, S. (2010). Maintaining a high physical activity level over 20 years and weight gain. *JAMA, 304*(23), 2603-2610.
- Hardeman, W., Griffin, S., Johnston, M., Kinmonth, A. L., & Wareham, N. J. (2000). Interventions to prevent weight gain: a systematic review of psychological models and behaviour change methods. *International Journal of Obesity, 24*(2), 131-143. doi: 10.1038/sj.ijo.0801100
- Harms, C., Young, J. R., Amsler, F., Zettler, C., Scheidegger, D., & Kindler, C. H. (2004). Improving anaesthetists' communication skills. *Anaesthesia, 59*(2), 166-172.
- Harper, D. (2002). Talking about pictures: a case for photo elicitation. *Visual studies, 17*(1), 13-26.

- Harvey-Berino, J., Pintauro, S., Buzzell, P., & Gold, E. C. (2004). Effect of internet support on the long-term maintenance of weight loss. *Obesity research, 12*(2), 320-329.
- Hawkins, J. D., & Weis, J. G. (1985). The social development model: An integrated approach to delinquency prevention. *Journal of Primary Prevention, 6*(2), 73-97.
- Hayes, S. C., Luoma, J. B., Bond, F. W., Masuda, A., & Lillis, J. (2006). Acceptance and commitment therapy: Model, processes and outcomes. *Behaviour research and therapy, 44*(1), 1-25.
- Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (1999). *Acceptance and commitment therapy: An experiential approach to behavior change*: Guilford Press.
- Heckathorn, D. D. (1990). Collective sanctions and compliance norms: A formal theory of group-mediated social control. *American Sociological Review, 366-384*.
- Heckhausen, J. (2007). The motivation-volition divide and its resolution in action-phase models of developmental regulation. *Research in Human Development, 4*(3-4), 163-180.
- Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). *Experience sampling method: Measuring the quality of everyday life*: Sage.
- Hendershot, C. S., Witkiewitz, K., George, W. H., & Marlatt, G. A. (2011). Relapse prevention for addictive behaviors. *Substance Abuse Treatment Prevention and Policy, 6*. doi: 10.1186/1747-597x-6-17
- Henry, S. G., & Fetters, M. D. (2012). Video elicitation interviews: a qualitative research method for investigating physician-patient interactions. *The Annals of Family Medicine, 10*(2), 118-125.
- Herman, C. P., & Polivy, J. (2004). The self-regulation of eating: Theoretical and practical problems.
- Hermanowicz, J. C. (2013). The longitudinal qualitative interview. *Qualitative sociology, 36*(2), 189-208.
- Heron, K. E., & Smyth, J. M. (2010). Ecological momentary interventions: incorporating mobile technology into psychosocial and health behaviour treatments. *British journal of health psychology, 15*(1), 1-39.
- Herriot, A. M., Thomas, D. E., Hart, K. H., Warren, J., & Truby, H. (2008). A qualitative investigation of individuals' experiences and expectations before

- and after completing a trial of commercial weight loss programmes. *Journal of Human Nutrition and Dietetics*, 21(1), 72-80.
- Higgins, E. T. (2005). Value from regulatory fit. *Current Directions in Psychological Science*, 14(4), 209-213.
- Higgins, E. T. (2006). Value from regulatory fit. *Current Directions in Psychological Science*, 14(4), 209-213
- Hill, J. O., Thompson, H., & Wyatt, H. (2005). Weight maintenance: what's missing? *Journal of the American Dietetic Association*, 105(5), 63-66.
- Hinton, P. R., McMurray, I., & Brownlow, C. (2014). *SPSS explained*: Routledge.
- Hobbs, N., Dixon, D., Johnston, M., & Howie, K. (2013). Can the theory of planned behaviour predict the physical activity behaviour of individuals? *Psychology & Health*, 28(3), 234-249.
- Hobbs, N., Godfrey, A., Lara, J., Errington, L., Meyer, T., Rochester, L., . . . Sniehotta, F. (2013). Are behavioral interventions effective in increasing physical activity at 12 to 36 months in adults aged 55 to 70 years? a systematic review and meta-analysis. *BMC Medicine*, 11(1), 75.
- Hodgetts, D., Radley, A., Chamberlain, K., & Hodgetts, A. (2007). Health Inequalities and Homelessness Considering Material, Spatial and Relational Dimensions. *Journal of Health Psychology*, 12(5), 709-725.
- Hofmann, W., Friese, M., & Wiers, R. W. (2008). Impulsive versus reflective influences on health behavior: a theoretical framework and empirical review. *Health Psychology Review*, 2(2), 111-137
- Holey, P. N., & Gaikwad, V. T. (2014). Google Glass Technology. *International Journal*, 2(3).
- Honaker, J., & King, G. (2010). What to do about missing values in time-series cross-section data. *American Journal of Political Science*, 54(2), 561-581.
- Horne, M., & Tierney, S. (2012). What are the barriers and facilitators to exercise and physical activity uptake and adherence among South Asian older adults: A systematic review of qualitative studies. *Preventive Medicine*, 55(4), 276-284.
- Hoss, L. G. (1985). *Intrinsic motivation and cognitive evaluation theory: application to counseling and maintenance of behavior change*. State University of New

York at Albany, Department of Counseling Psychology and Student Development.

- Hughes, J. R., Keely, J., & Naud, S. (2004). Shape of the relapse curve and long-term abstinence among untreated smokers. *Addiction, 99*(1), 29-38. doi: 10.1111/j.1360-0443.2004.00540.x
- Hunt, S. M., & Martin, C. J. (1988). Health-related behavioural change—A test of a new model. *Psychology and Health, 2*, 209-230.
- Ikeda, J., Amy, N. K., Ernsberger, P., Gaesser, G. A., Berg, F. M., Clark, C. A., . . . Peters, P. (2005). The national weight control registry: a critique. *Journal of nutrition education and behavior, 37*(4), 203-205.
- Jeffery, R. W., Wing, R. R., Sherwood, N. E., & Tate, D. F. (2003). Physical activity and weight loss: does prescribing higher physical activity goals improve outcome? *The American journal of clinical nutrition, 78*(4), 684-689.
- Jessor, R., & Jessor, S. (1977). *Problem behavior and psychosocial development: A longitudinal study of youth*. New York: Academic Press.
- Johnston, D. W., & Johnston, M. (2013). Useful theories should apply to individuals. *British journal of health psychology, 18*(3), 469-473.
- Jolly, K., Lewis, A., Beach, J., Denley, J., Adab, P., Deeks, J. J., . . . Aveyard, P. (2011). Comparison of range of commercial or primary care led weight reduction programmes with minimal intervention control for weight loss in obesity: Lighten Up randomised controlled trial. *BMJ, 343*.
- Jones, E. E. (1976). How Do People Perceive the Causes of Behavior? Experiments based on attribution theory offer some insights into how actors and observers differ in viewing the causal structure of their social world. *American Scientist, 300*-305.
- Kandel, E. R., Schwartz, J. H., & Jessell, T. M. (2000). *Principles of neural science* (Vol. 4): McGraw-Hill New York.
- Kanfer, F. H., & Gaelick-Buys. (1991). Self-management methods. In F. H. Kanfer & A. P. Goldstein (Eds.), *Helping people change: A textbook of methods* (pp. 305-360). New York: Pergamon Press.
- Kanfer, F. H., & Karoly, P. (1972). Self-control: A behavioristic excursion into the lion's den. *Behavior Therapy, 3*(3), 398-416. doi: 10.1016/S0005-7894(72)80140-0
- Karasek, R. A. (1979). Job demands, job decision latitude, and mental strain: Implications for job redesign. *Administrative science quarterly, 285*-308.



- Katz, D. L. (2001). Behavior modification in primary care: the pressure system model. *Preventive Medicine, 32*(1), 66-72.
- Katz, D. L., & Meller, S. (2014). Can We Say What Diet Is Best for Health? *Annual Review of Public Health, 35*(1).
- Kayman, S., Bruvold, W., & Stern, J. S. (1990). Maintenance and relapse after weight loss in women: behavioral aspects. *The American journal of clinical nutrition, 52*(5), 800-807.
- Kazdin, A. E. (2011). *Single-case research designs: Methods for clinical and applied settings*: Oxford University Press.
- Kazi, A. S., Wohlfart, L., & Wolf, P. (2007). *Hands-on Knowledge Co-creation and Sharing: Practical Methods & Techniques*. Verlag: Knowledge Board.
- Keller, C., Fleury, J., Perez, A., Ainsworth, B., & Vaughan, L. (2008). Using visual methods to uncover context. *Qualitative health research, 18*(3), 428-436.
- Kelly, J. A., Stlawrence, J. S., & Brasfield, T. L. (1991). Predictors of vulnerability to AIDS risk behavior relapse. *Journal of Consulting and Clinical Psychology, 59*(1), 163-166. doi: 10.1037/0022-006x.59.1.163
- Kelly, T., Yang, W., Chen, C. S., Reynolds, K., & He, J. (2008). Global burden of obesity in 2005 and projections to 2030. *International Journal of Obesity, 32*(9), 1431-1437.
- Kesby, M. (2000). Participatory diagramming as a means to improve communication about sex in rural Zimbabwe: a pilot study. *Social Science & Medicine, 50*(12), 1723-1741.
- Khaylis, A., Yiaslas, T., Bergstrom, J., & Gore-Felton, C. (2010). A review of efficacious technology-based weight-loss interventions: five key components. *Telemedicine and e-Health, 16*(9), 931-938.
- Kielhofner, G. (2002). *A model of human occupation: Theory and application*: Lippincott Williams & Wilkins.
- Klem, M. L., Wing, R. R., Lang, W., McGuire, M. T., & Hill, J. O. (2000). Does weight loss maintenance become easier over time? *Obesity research, 8*(6), 438-444.
- Klem, M. L., Wing, R. R., McGuire, M. T., Seagle, H. M., & Hill, J. O. (1997). A descriptive study of individuals successful at long-term maintenance of substantial weight loss. *The American journal of clinical nutrition, 66*(2), 239-246.

- Kremers, S. P. J., De Bruijn, G.-J., Visscher, T. L. S., Van Mechelen, W., De Vries, N. K., & Brug, J. (2006). Environmental influences on energy balance-related behaviors: a dual-process view. *International Journal of Behavioral Nutrition and Physical Activity*, 3(1), 9.
- Krippendorff, K. (2012). *Content analysis: An introduction to its methodology*: Sage.
- Kristal, A. R., White, E., Shattuck, A., Curry, S., Anderson, G. L., Fowler, A., & Urban, N. (1992). Long-term maintenance of a low-fat diet: durability of fat-related dietary habits in the Women's Health Trial. *Journal of the American Dietetic Association*, 92(5), 553-559.
- Kroeze, W., Werkman, A., & Brug, J. (2006). A systematic review of randomized trials on the effectiveness of computer-tailored education on physical activity and dietary behaviors. *Annals of Behavioral Medicine*, 31(3), 205-223.
- Kruger, J., Blanck, H. M., & Gillespie, C. (2006). Dietary and physical activity behaviors among adults successful at weight loss maintenance. *International Journal of Behavioral Nutrition and Physical Activity*, 3(1), 17.
- Kwasnicka, D., Dombrowski, S. U., White, M., & Sniehotta, F. F. (2014). *Qualitative study assessing technology usability in people who have participated in multimodal weight loss study*. Paper presented at the European Health Psychology Conference Innsbruck, Austria.
- Kwasnicka, D., Pesseau, J., White, M., & Sniehotta, F. F. (2013). Does planning how to cope with anticipated barriers facilitate health-related behaviour change? A systematic review. *Health Psychology Review*, 7(2), 129-145.
- Lachal, J., Speranza, M., Taïeb, O., Falissard, B., Lefèvre, H., Moro, M.-R., & Revah-Levy, A. (2012). Qualitative research using photo-elicitation to explore the role of food in family relationships among obese adolescents. *Appetite*, 58(3), 1099-1105.
- Lake, A., & Townshend, T. (2006). Obesogenic environments: exploring the built and food environments. *The Journal of the Royal society for the Promotion of Health*, 126(6), 262-267.
- Lally, P., Chipperfield, A., & Wardle, J. (2007). Healthy habits: efficacy of simple advice on weight control based on a habit-formation model. *International Journal of Obesity*, 32(4), 700-707.
- Lally, P., Van Jaarsveld, C. H. M., Potts, H. W. W., & Wardle, J. (2010). How are habits formed: Modelling habit formation in the real world. *European Journal of Social Psychology*, 40(6), 998-1009. doi: 10.1002/ejsp.674

- LaRose, J. G., Fava, J. L., Steeves, E. A., Hecht, J., Wing, R. R., & Raynor, H. A. (2013). Daily Self-Weighing Within a Lifestyle Intervention: Impact on Disordered Eating Symptoms.
- Larsson, U. E. (2003). Influence of weight loss on pain, perceived disability and observed functional limitations in obese women. *International Journal of Obesity*, 28(2), 269-277.
- Lawton, J., Peel, E., Parry, O., & Douglas, M. (2008). Shifting accountability: a longitudinal qualitative study of diabetes causation accounts. *Social Science & Medicine*, 67(1), 47-56.
- Lequerica, A. H., & Kortte, K. (2010). Therapeutic engagement: a proposed model of engagement in medical rehabilitation. *American journal of physical medicine & rehabilitation*, 89(5), 415-422.
- Leventhal, H., Brissette, I., & Leventhal, E. A. (2003). The common-sense model of self-regulation of health and illness. *The self-regulation of health and illness behaviour*, 1, 42-65.
- Lewin, K. (1951). *Field theory in social science: Selected theoretical papers*. New York: Harper & Row.
- Linde, J. A., Jeffery, R. W., Finch, E. A., Ng, D. M., & Rothman, A. J. (2004). Are unrealistic weight loss goals associated with outcomes for overweight women? *Obesity research*, 12(3), 569-576.
- Locke, E. A., & Latham, G. P. (2002). Building a Practically Useful Theory of Goal Setting and Task Motivation. A 35 Year Odyssey. *American Psychologist*, 57(9), 705-717.
- Lowe, M. R., Tappe, K. A., Annunziato, R. A., Riddell, L. J., Coletta, M. C., Crerand, C. E., . . . McKinney, S. (2008). The Effect of Training in Reduced Energy Density Eating and Food Self-monitoring Accuracy on Weight Loss Maintenance. *Obesity*, 16(9), 2016-2023.
- Lustria, M. L. A., Cortese, J., Noar, S. M., & Glueckauf, R. L. (2009). Computer-tailored health interventions delivered over the Web: review and analysis of key components. *Patient education and counseling*, 74(2), 156-173.
- Madigan, C. D., Aveyard, P., Jolly, K., Denley, J., Lewis, A., & Daley, A. J. (2013). Regular self-weighing to promote weight maintenance after intentional weight loss: a quasi-randomized controlled trial. *Journal of Public Health*, fdt061.
- Madigan, C. D., Jolly, K., Lewis, A. L., Aveyard, P., & Daley, A. J. (2014). A randomised controlled trial of the effectiveness of self-weighing as a weight loss

- intervention. *International Journal of Behavioral Nutrition and Physical Activity*, 11(1), 125.
- Malpass, A., Andrews, R., & Turner, K. M. (2009). Patients with type 2 diabetes experiences of making multiple lifestyle changes: a qualitative study. *Patient education and counseling*, 74(2), 258-263.
- Manson, J. E., Skerrett, P. J., Greenland, P., & VanItallie, T. B. (2004). The escalating pandemics of obesity and sedentary lifestyle: a call to action for clinicians. *Archives of Internal Medicine*, 164(3), 249-258.
- Markus, H. (1977). Self-schemata and processing information about self. *Journal of Personality and Social Psychology*, 35(2), 63-78. doi: 10.1037//0022-3514.35.2.63
- Marlatt, G. A., & Donovan, D. M. (2005). *Relapse prevention: Maintenance strategies in the treatment of addictive behaviors*: Guilford Press.
- Marlatt, G. A., & George, W. H. (1984). Relapse prevention - introduction and overview of the model. *British Journal of Addiction*, 79(3), 261-273.
- May, C., & Finch, T. (2009). Implementing, Embedding, and Integrating Practices: An Outline of Normalization Process Theory. *Sociology-the Journal of the British Sociological Association*, 43(3), 535-554. doi: 10.1177/0038038509103208
- May, C. R., Mair, F., Finch, T., MacFarlane, A., Dowrick, C., Treweek, S., . . . Montori, V. M. (2009). Development of a theory of implementation and integration: Normalization Process Theory. *Implementation Science*, 4. doi: 10.1186/1748-5908-4-29
- McDonald, S., Hobbs, N., White, W., & Sniehotta, F. F. (2014). *Using n-of-1 methodology to examine intra-individual changes in physical activity behaviour during the transition from employment to retirement*. Paper presented at the UK Society for Behavioural Medicine Conference, Nottingham, UK.
- McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis. *Health Psychology Review*, 5(2), 97-144.
- McGuire, W. J. (1976). Some internal psychological factors influencing consumer choice. *Journal of Consumer Research*, 302-319.
- McKee, H., Ntoumanis, N., & Smith, B. (2013). Weight maintenance: Self-regulatory factors underpinning success and failure. *Psychology & Health*, 28(10), 1207-1223.

- McKinlay, J. B. (1995). The new public health approach to improving physical activity and autonomy in older populations *Preparation for aging* (pp. 87-103): Springer.
- McLeroy, K. R., Bibeau, D., Steckler, A., & Glanz, K. (1988). An ecological perspective on health promotion programs. *Health Education Behavior, 15*(4), 351-377.
- Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: Dynamics of willpower. *Psychological Review, 106*(1), 3-19. doi: 10.1037/0033-295x.106.1.3
- Michie, S., Ashford, S., Sniehotta, F. F., Dombrowski, S. U., Bishop, A., & French, D. P. (2011). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: The CALO-RE taxonomy. *Psychology & Health, 26*(11), 1479-1498. doi: 10.1080/08870446.2010.540664
- Michie, S., Campbell, R., Brown, J., & West, R. (2014). *ABC of Behaviour Change Theories*. London: Silverback Publishing.
- Michie, S., Hyder, N., Walia, A., & West, R. (2011). Development of a taxonomy of behaviour change techniques used in individual behavioural support for smoking cessation. *Addictive Behaviors, 36*(4), 315-319. doi: 10.1016/j.addbeh.2010.11.016
- Michie, S., & Johnston, M. (2012). Theories and techniques of behaviour change: Developing a cumulative science of behaviour change. *Health Psychology Review, 6*(1), 1-6. doi: 10.1080/17437199.2012.654964
- Michie, S., Johnston, M., Abraham, C., Lawton, R., Parker, D., Walker, A., & Psychological Theory, G. (2005). Making psychological theory useful for implementing evidence based practice: a consensus approach. *Quality & Safety in Health Care, 14*(1), 26-33. doi: 10.1136/qshc.2004.011155
- Michie, S., Johnston, M., Francis, J., Hardeman, W., & Eccles, M. (2008). From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques. *Applied psychology, 57*(4), 660-680.
- Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation Science, 6*(1), 42.
- Michie, S., Whittington, C., Hamoudi, Z., Zarnani, F., Tober, G., & West, R. (2012). Identification of behaviour change techniques to reduce excessive alcohol consumption. *Addiction, 107*(8), 1431-1440. doi: 10.1111/j.1360-0443.2012.03845.x

- Miller, D. (2008). *The Comfort of Things*. Cambridge: Polity.
- Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of Internal Medicine*, *151*(4), 264-269.
- Moos, R. H., & Moos, B. S. (2006). Rates and predictors of relapse after natural and treated remission from alcohol use disorders. *Addiction*, *101*(2), 212-222. doi: 10.1111/j.1360-0443.2006.01310.x
- Morris, J., Oliver, T., Kroll, T., & MacGillivray, S. (2011). The importance of psychological and social factors in influencing the uptake and maintenance of physical activity after stroke: a structured review of the empirical literature. *Stroke research and treatment*, *2012*.
- Moss, A. C., & Albery, I. P. (2009). A Dual-Process Model of the Alcohol-Behavior Link for Social Drinking. *Psychological Bulletin*, *135*(4), 516-530. doi: 10.1037/a0015991
- Muraven, M., & Baumeister, R. F. (2000). Self-Regulation and Depletion of Limited Resources: Does Self-Control Resemble a Muscle? *Psychological Bulletin*, *126*(2), 247-259. doi: 10.1037//0033-2909.126.2.247
- Najmi, E., Hashmi, K., Khazalah, F., & Malik, Z. (2013). *Intelligent semantic question answering system*. Paper presented at the Cybernetics (CYBCONF), 2013 IEEE International Conference on.
- Nederkoorn, C., Houben, K., Hofmann, W., Roefs, A., & Jansen, A. (2010). Control Yourself or Just Eat What You Like? Weight Gain Over a Year Is Predicted by an Interactive Effect of Response Inhibition and Implicit Preference for Snack Foods. *Health Psychology*, *29*(4), 389-393. doi: 10.1037/a0019921
- Neff, J. A., & MacMaster, S. A. (2005). Applying behaviour change models to understand spiritual mechanisms underlying change in substance abuse treatment. *The American Journal of Drug and Alcohol Abuse*, *31*, 669-684.
- Neve, M., Morgan, P. J., Jones, P. R., & Collins, C. E. (2010). Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis. *Obesity Reviews*, *11*(4), 306-321.
- Newham, J. J., Presseau, J., Araujo-Soares, V., & Sniehotta, F. F. (2014). *Promoting physical activity in people with Type 2 Diabetes: Findings of an N-of-1 study*. Paper presented at the European Health Psychology Society Conference, Innsbruck, Austria.

- NICE. (2012a). *Obesity: working with local communities*. Retrieved from <http://publications.nice.org.uk/obesity-working-with-local-communities-ph42>.
- NICE. (2012b). *Walking and cycling: local measures to promote walking and cycling as forms of travel or recreation*. Retrieved from <http://publications.nice.org.uk/walking-and-cycling-local-measures-to-promote-walking-and-cycling-as-forms-of-travel-or-recreation-ph41>.
- NICE. (2014a). *Behaviour change: individual approaches*. Retrieved from <http://publications.nice.org.uk/behaviour-change-individual-approaches-ph49>.
- NICE. (2014b). *Managing overweight and obesity in adults – lifestyle weight management services*. Retrieved from <https://www.nice.org.uk/guidance/ph53>.
- Nigg, C. R., Borrelli, B., Maddock, J., & Dishman, R. K. (2008). A theory of physical activity maintenance. *Applied psychology, 57*(4), 544-560.
- Noar, S. M., Benac, C. N., & Harris, M. S. (2007). Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychological Bulletin, 133*(4), 673.
- Odutolu, O. (2005). Convergence of behaviour change models for AIDS risk reduction in sub-Saharan Africa. *The International journal of health planning and management, 20*(3), 239-252.
- Ogden, J., & Hills, L. (2008). Understanding sustained behavior change: the role of life crises and the process of reinvention. *Health, 12*(4), 419-437. doi: 10.1177/1363459308094417
- Ohsiek, S., & Williams, M. (2011). Psychological factors influencing weight loss maintenance: an integrative literature review. *Journal of the American Academy of Nurse Practitioners, 23*(11), 592-601.
- Okorodudu, D. E., Bosworth, H. B., & Corsino, L. (2014). Innovative interventions to promote behavioral change in overweight or obese individuals: A review of the literature. *Annals of medicine*(0), 1-7.
- Oliver, M., Badland, H., Mavoa, S., Duncan, M. J., & Duncan, S. (2010). Combining GPS, GIS, and accelerometry: methodological issues in the assessment of location and intensity of travel behaviors. *Journal of physical activity & health, 7*(1).

- Orr, J. A., & King, R. J. (2015). Mobile phone SMS messages can enhance healthy behaviour: a meta-analysis of randomised controlled trials. *Health Psychology Review*(just-accepted), 1-36.
- Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior. *Psychological Bulletin*, 124(1), 54.
- Pagoto, S., & Bennett, G. G. (2013). How behavioral science can advance digital health. *Translational Behavioral Medicine*, 3(3), 271-276.
- Pagoto, S., Schneider, K., Jovic, M., DeBiase, M., & Mann, D. (2013). Evidence-based strategies in weight-loss mobile apps. *American journal of preventive medicine*, 45(5), 576-582.
- Pagoto, S., Schneider, K., Oleski, J., Smith, B., & Bauman, M. (2013). The adoption and spread of a core-strengthening exercise through an online social network. *Journal of Physical Activity and Health*.
- Pagoto, S., Turner-McGrievy, G., Evans, M., Sepah, C., & Nilson, W. (2014). *Weight Loss in the Age of Social Media: Twitter, FaceBook, and Blogging*. Paper presented at the Annals of Behavioral Medicine.
- Panter-Brick, C., Clarke, S. E., Lomas, H., Pinder, M., & Lindsay, S. W. (2006). Culturally compelling strategies for behaviour change: A social ecology model and case study in malaria prevention. *Social Science & Medicine*, 62, 2810-2825.
- Papa, M. J., Singhal, A., & Papa, W. H. (2006). *Organizing for social change: A dialectic journey of theory and praxis*: Sage.
- Park, C. L., & Gaffey, A. E. (2007). Relationships between psychosocial factors and health behavior change in cancer survivors: an integrative review. *Annals of Behavioral Medicine*, 34(2), 115-134.
- Pascoe, J. (2006). *The Smartwatch*. Paper presented at the Proceedings of the Conference on Mobile and Ubiquitous Systems (CSMU), Guimaraes Portugal.
- Pasman, W. J., Saris, W. H. M., & Westerterp-Plantenga, M. S. (1999). Predictors of weight maintenance. *Obesity research*, 7(1), 43-50.
- Patton, M. Q. (2002). Two decades of developments in qualitative inquiry a personal, experiential perspective. *Qualitative Social Work*, 1(3), 261-283.
- Pavlov, I. P. (1927). *Conditioned Reflexes*. London: Oxford University Press.



- Pbert, L. (2013). *The handbook of health behavior change*. New York: Springer Publishing Company.
- Penn, L., White, M., Lindström, J., den Boer, A. T., Blaak, E., Eriksson, J. G., . . . Walker, M. (2013). Importance of weight loss maintenance and risk prediction in the prevention of type 2 diabetes: analysis of European Diabetes Prevention Study RCT. *PloS one*, *8*(2), e57143.
- Perri, M. G., Nezu, A. M., McKelvey, W. F., Shermer, R. L., Renjilian, D. A., & Viegner, B. J. (2001). Relapse prevention training and problem-solving therapy in the long-term management of obesity. *Journal of Consulting and Clinical Psychology*, *69*(4), 722.
- Peters, J. C., Wyatt, H. R., Donahoo, W. T., & Hill, J. O. (2002). From instinct to intellect: the challenge of maintaining healthy weight in the modern world. *Obesity Reviews*, *3*(2), 69-74.
- Petty, R. E., & Cacioppo, J. T. (1986). The elaboration likelihood model of persuasion. *Advances in experimental social psychology*, *19*, 123-205.
- Pindyck, R. S., & Rubinfeld, D. L. (1998). *Econometric models and economic forecasts* (Vol. 4): Irwin/McGraw-Hill Boston.
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*(5), 879.
- Poirier, P., Giles, T. D., Bray, G. A., Hong, Y. L., Stern, J. S., Pi-Sunyer, F. X., & Eckel, R. H. (2006). Obesity and cardiovascular disease: Pathophysiology, evaluation, and effect of weight loss - An update of the 1997 American Heart Association Scientific Statement on obesity and heart disease from the Obesity Committee of the Council on Nutrition, Physical Activity, and Metabolism. *Circulation*, *113*(6), 898-918. doi: Doi 10.1161/Circulationaha.106.171016
- Polivy, J., & Herman, C. P. (1985). Dieting and binge eating: A causal analysis. . *American Psychologist*, *40*, 193–204.
- Poobalan, A. S., Aucott, L. S., Precious, E., Crombie, I. K., & Smith, W. C. S. (2010). Weight loss interventions in young people (18 to 25 year olds): a systematic review. *Obesity Reviews*, *11*(8), 580-592.
- Prentice, A., & Jebb, S. (2004). Energy intake/physical activity interactions in the homeostasis of body weight regulation. *Nutrition reviews*, *62*(s2), S98-S104.

- Presseau, J., Sniehotta, F. F., Francis, J. J., & Campbell, N. C. (2009). Multiple goals and time constraints: perceived impact on physicians' performance of evidencebased behaviours. *Implement Sci*, 4(77), 77.
- Presseau, J., Sniehotta, F. F., Francis, J. J., & Little, B. R. (2008). Personal project analysis: opportunities and implications for multiple goal assessment, theoretical integration, and behaviour change.
- Prestwich, A., Sniehotta, F. F., Whittington, C., Dombrowski, S. U., Rogers, L., & Michie, S. (2014). Does theory influence the effectiveness of health behavior interventions? Meta-analysis. *Health Psychology*, 33(5), 465.
- Prochaska, J. O., & Di Clemente, C. C. (1983). Stages and processes of self-change of smoking: Toward an integrative model of change. *Journal of Consulting and Clinical Psychology & Health*, 51(3), 390-395.
- Prochaska, J. O., DiClemente, C., C. , & Norcross, J. C. (1992). In search of how people change: Applications to addictive behaviors. *American Psychologist*, 47(9), 1102-1114.
- Pronk, N. P., & Wing, R. R. (1994). Physical Activity and Long-Term Maintenance of Weight Loss. *Obesity research*, 2(6), 587-599.
- Prosser, J., & Loxley, A. (2008). *Introducing visual methods (NCRM Review Paper)*. Southampton: National Centre for Research Methods.
- Quinn, F., Johnston, M., & Johnston, D. W. (2013). Testing an integrated behavioural and biomedical model of disability in N-of-1 studies with chronic pain. *Psychology & Health*, 28(12), 1391-1406. doi: 10.1080/08870446.2013.814773
- Radley, A., & Bell, S. E. (2007). Artworks, collective experience and claims for social justice: The case of women living with breast cancer. *Sociology of health & illness*, 29(3), 366-390.
- Reyes, N. R., Oliver, T. L., Klotz, A. A., LaGrotte, C. A., Vander Veur, S. S., Virus, A., . . . Foster, G. D. (2012). Similarities and differences between weight loss maintainers and regainers: a qualitative analysis. *Journal of the Academy of Nutrition and Dietetics*, 112(4), 499-505.
- Rodrigues, A. M., O'Brien, N., French, D. P., Glidewell, L., & Sniehotta, F. F. (2014). The Question–Behavior Effect: Genuine Effect or Spurious Phenomenon? A Systematic Review of Randomized Controlled Trials With Meta-Analyses.
- Rogers, E. M. (2010). *Diffusion of innovations*: Simon and Schuster.

- Rogers, R. W. (1975). A protection motivation theory of fear appeals and attitude change. *The journal of psychology, 91*(1), 93-114.
- Rogers, R. W., & Prentice-Dunn, S. (1997). Protection motivation theory.
- Rokeach, M. (1968). Beliefs, attitudes and values: A theory of organization and change.
- Romer, D., & Hornik, R. (1992). HIV education for youth: the importance of social consensus in behaviour change. *AIDS care, 4*(3), 285-303.
- Rosenstock, I. M. (1974). Historical origins of the health belief model. *Health Education & Behavior, 2*(4), 328-335.
- Ross Middleton, K. M., Patidar, S. M., & Perri, M. G. (2012). The impact of extended care on the long-term maintenance of weight loss: a systematic review and meta-analysis. *Obesity Reviews, 13*(6), 509-517.
- Rothman, A. J. (2000). Toward a theory-based analysis of behavioral maintenance. *Health Psychology, 19*(1), 64-69. doi: 10.1037//0278-6133.19.Supp1.64
- Rothman, A. J. (2004). "Is there nothing more practical than a good theory?": Why innovations and advances in health behavior change will arise if interventions are used to test and refine theory. *International Journal of Behavioral Nutrition and Physical Activity, 1*(1), 11.
- Rothman, A. J. (2004). "Is there nothing more practical than a good theory?": Why innovations and advances in health behavior change will arise if interventions are used to test and refine theory. *International Journal of Behavioral Nutrition and Physical Activity, 11*, 1-7. doi: 10.1186/1479-5868-1-11
- Rothman, A. J., Baldwin, A. S., & Hertel, A. W. (2004). Self-regulation and Behavior Change: Disentangling Behavioral Initiation and Behavioral Maintenance In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of Self-Regulation* (pp. 130-1150). London: The Guilford Press.
- Rothman, A. J., Sheeran, P., & Wood, W. (2009). Reflective and Automatic Processes in the Initiation and Maintenance of Dietary Change. *Annals of Behavioral Medicine, 38*, S4-S17. doi: 10.1007/s12160-009-9118-3
- Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development and well-being. *American Psychologist, 55*, 68-78.

- Saba, G. W., Wong, S. T., Schillinger, D., Fernandez, A., Somkin, C. P., Wilson, C. C., & Grumbach, K. (2006). Shared decision making and the experience of partnership in primary care. *The Annals of Family Medicine*, 4(1), 54-62.
- Salvy, S.-J., Bowker, J. W., Roemmich, J. N., Romero, N., Kieffer, E., Paluch, R., & Epstein, L. H. (2008). Peer influence on children's physical activity: an experience sampling study. *Journal of pediatric psychology*, 33(1), 39-49.
- Samuels, J. (2004). Breaking the Ethnographer's Frames Reflections on the Use of Photo Elicitation in Understanding Sri Lankan Monastic Culture. *American behavioral scientist*, 47(12), 1528-1550.
- Sarlio-Lähteenkorva, S., Rissanen, A., & Kaprio, J. (2000). A descriptive study of weight loss maintenance: 6 and 15 year follow-up of initially overweight adults. *International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity*, 24(1), 116-125.
- Schulz, A., & Northridge, M. E. (2004). Social determinants of health: implications for environmental health promotion. *Health Education & Behavior*, 31(4), 455-471.
- Schwarzer, R. (1992). Self-efficacy in the adoption and maintenance of health behaviors: Theoretical approaches and a new model. In R. Schwarzer (Ed.), *Self-efficacy: Thought control of action* (pp. 217-243). Washington, DC: Hemisphere.
- Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology-an International Review-Psychologie Appliquee-Revue Internationale*, 57(1), 1-29. doi: 10.1111/j.1464-0597.2007.00325.x
- Shamseer, L., Sampson, M., Bukutu, C., Schmid, C. H., Nikles, J., Tate, R., . . . Kravitz, R. (2015). CONSORT extension for reporting N-of-1 trials (CENT) 2015: Explanation and elaboration. *BMJ*, 350, h1793.
- Shaw, R., & Bosworth, H. (2012). Short message service (SMS) text messaging as an intervention medium for weight loss: A literature review. *Health informatics journal*, 18(4), 235-250.
- Sheeran, P., Gollwitzer, P. M., & Bargh, J. A. (2013). Nonconscious processes and health. *Health Psychology*, 32(5), 460.
- Sheridan, J., & Chamberlain, K. (2011). The power of things. *Qualitative Research in Psychology*, 8(4), 315-332.

- Sheridan, J., Chamberlain, K., & Dupuis, A. (2011). Timelining: visualizing experience. *Qualitative Research, 11*(5), 552-569.
- Shick, S. M., Wing, R. R., Klem, M. L., McGuire, M. T., Hill, J. O., & Seagle, H. (1998). Persons successful at long-term weight loss and maintenance continue to consume a low-energy, low-fat diet. *Journal of the American Dietetic Association, 98*(4), 408-413.
- Shiffman, S. (2005). Dynamic influences on smoking relapse process. *Journal of personality, 73*(6), 1715-1748.
- Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annu. Rev. Clin. Psychol., 4*, 1-32.
- Simpson, S. A., Shaw, C., & McNamara, R. (2011). What is the most effective way to maintain weight loss in adults. *BMJ, 343*(d8042), 1-3.
- Skinner, B. F. (1953). *Science and human behaviour*. New York: Macmillan.
- Sniehotta, F. F., Penseau, J., & Araújo-Soares, V. (2014). Time to retire the theory of planned behaviour. *Health Psychology Review, 8*(1), 1-7.
- Sniehotta, F. F., Penseau, J., & Araújo-Soares, V. (in press). On the development, evaluation and evolution of behaviour change theory. . *Health Psychology Review, 23*. doi: 10.1080/17437199.2015.1022902
- Sniehotta, F. F., Penseau, J., Hobbs, N., & Araujo-Soares, V. (2012). Testing Self-Regulation Interventions to Increase Walking Using Factorial Randomized N-of-1 Trials. *Health Psychology, 31*(6), 733-737. doi: 10.1037/a0027337
- Sniehotta, F. F., Schwarzer, R., Scholz, U., & Schuz, B. (2005). Action planning and coping planning for long-term lifestyle change: Theory and assessment. *European Journal of Social Psychology, 35*(4), 565-576. doi: 10.1002/ejsp.258
- Sniehotta, F. F., Simpson, S. A., & Greaves, C. J. (2014). Weight loss maintenance: An agenda for health psychology. *British journal of health psychology, 19*(3), 459-464.
- Spencer, L., Ritchie, J., & O'Connor, W. (2003). Analysis: practices, principles and processes. *Qualitative research practice: A guide for social science students and researchers, 199-218*.
- Stasiewicz, P. R., & Maisto, S. A. (1993). Two-Factor Avoidance Theory: The Role of Negative Affect in the Maintenance of Substance Use and Substance Use Disorder. *Behavior Therapy, 24*, 337-356.

- Stephens, M. A. P., Franks, M. M., Rook, K. S., Iida, M., Hemphill, R. C., & Salem, J. K. (2013). Spouses' attempts to regulate day-to-day dietary adherence among patients with type 2 diabetes. *Health Psychology, 32*(10), 1029.
- Stephens, M. A. P., Rook, K. S., Franks, M. M., Khan, C., & Iida, M. (2010). Spouses use of social control to improve diabetic patients' dietary adherence. *Families, Systems, & Health, 28*(3), 199.
- Stevens, J., Truesdale, K. P., McClain, J. E., & Cai, J. (2005). The definition of weight maintenance. *International Journal of Obesity, 30*(3), 391-399.
- Stevens, M., Bult, P., de Greef, M. H. G., Lemmink, K., & Rispens, P. (1999). Groningen active living model (GALM): Stimulating physical activity in sedentary older adults. *Preventive Medicine, 29*(4), 267-276. doi: 10.1006/pmed.1999.0545
- Stokols, D. (1992). Establishing and maintaining healthy environments: toward a social ecology of health promotion. *American Psychologist, 47*(1), 6.
- Stone, A. A., Shiffman, S. S., & DeVries, M. W. (1999). Ecological momentary assessment.
- Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8*(3), 220-247.
- Stroebe, W., Mensink, W., Aarts, H., Schut, H., & Kruglanski, A. W. (2008). Why dieters fail: Testing the goal conflict model of eating. *Journal of Experimental Social Psychology, 44*(1), 26-36. doi: 10.1016/j.jesp.2007.01.005
- Sutin, A. R., Ferrucci, L., Zonderman, A. B., & Terracciano, A. (2011). Personality and obesity across the adult life span. *Journal of Personality and Social Psychology, 101*(3), 579.
- Svetkey, L. P., Stevens, V. J., Brantley, P. J., Appel, L. J., Hollis, J. F., Loria, C. M., . . . Smith, P. (2008). Comparison of strategies for sustaining weight loss: the weight loss maintenance randomized controlled trial. *JAMA, 299*(10), 1139-1148.
- Swinburn, B., Egger, G., & Raza, F. (1999). Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Preventive Medicine, 29*(6), 563-570.
- Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L., & Gortmaker, S. L. (2011). The global obesity pandemic: shaped by global drivers and local environments. *The Lancet, 378*(9793), 804-814.

- Tajfel, H., & Turner, J. (1979). An integrative theory of intergroup conflict. In W. G. Austin & S. Worchel (Eds.), *The Social Psychology of Intergroup Relations*. Monterey, CA: Brooks-Cole.
- Takacs, J., Pollock, C. L., Guenther, J. R., Bahar, M., Napier, C., & Hunt, M. A. (2013). Validation of the Fitbit One activity monitor device during treadmill walking. *Journal of Science and Medicine in Sport*.
- Tan, K. C. B. (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *The Lancet*, 363(9403), 157-163.
- Thaler, R. H., & Sunstein, C. R. (2008). *Nudge*: Yale University Press.
- Thompson, B., & Kinne, S. (1990). Social change theory: applications to community health. In N. Bracht (Ed.), *Health promotion at the community level*. Newbury Park: Sage Publications.
- Thompson, M., & Oelker, A. (2013). Use of Participant-Generated Photographs Versus Time Use Diaries as a Method of Qualitative Data Collection. *International Journal of Qualitative Methods*, 12, 624-637.
- Thorpe, O., Johnston, K., & Kumar, S. (2012). Barriers and enablers to physical activity participation in patients with COPD: a systematic review. *Journal of cardiopulmonary rehabilitation and prevention*, 32(6), 359-369.
- Triandis, H. C. (1977). *Interpersonal behavior*. Monterey: Brooks/Cole Publishing Company.
- Tsai, A. G., & Wadden, T. A. (2005). Systematic review: An evaluation of major commercial weight loss programs in the United States. *Annals of Internal Medicine*, 142(1), 56-66.
- Turner, J. C. (1987). *Rediscovering the social group: a Self-Categorization Theory*. Oxford: Blackwell Ltd.
- van Dam, H. A., van der Horst, F. G., Knoops, L., Ryckman, R. M., Crebolder, H. F. J. M., & van den Borne, B. H. W. (2005). Social support in diabetes: a systematic review of controlled intervention studies. *Patient education and counseling*, 59(1), 1-12.
- van Stralen, M. M., De Vries, H., Mudde, A. N., Bolman, C., & Lechner, L. (2009). Determinants of initiation and maintenance of physical activity among older adults: a literature review. *Health Psychology Review*, 3(2), 147-207.

- Vancouver, J. B., & Kendall, L. N. (2006). When self-efficacy negatively relates to motivation and performance in a learning context. *Journal of Applied Psychology, 91*(5), 1146.
- Vancouver, J. B., Thompson, C. M., Tischner, E. C., & Putka, D. J. (2002). Two studies examining the negative effect of self-efficacy on performance. *Journal of Applied Psychology, 87*(3), 506.
- Vangeli, E., Stapleton, J., Smit, E. S., Borland, R., & West, R. (2011). Predictors of attempts to stop smoking and their success in adult general population samples: a systematic review. *Addiction, 106*(12), 2110-2121.
- Vaughan, P. W., & Rogers, E. M. (2000). A staged model of communication effects: Evidence from an entertainment-education radio soap opera in Tanzania. *Journal of health communication, 5*(3), 203-227.
- Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision sciences, 39*(2), 273-315.
- Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: four longitudinal field studies. *Management science, 46*(2), 186-204.
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly, 425-478*.
- Verplanken, B. (2006). Beyond frequency: Habit as mental construct. *British Journal of Social Psychology, 45*, 639-656. doi: 10.1348/014466605x49122
- Verplanken, B., & Aarts, H. (1999). Habit, Attitude, and Planned Behaviour: Is Habit an Empty Construct or an Interesting Case of Goal-directed Automaticity? *European Review of Social Psychology, 10*(1), 101-134. doi: 10.1080/14792779943000035
- Verplanken, B., & Faes, S. (1999). Good intentions, bad habits, and effects of forming implementation intentions on healthy eating. *European Journal of Social Psychology, 29*(5-6), 591-604.
- Verplanken, B., & Orbell, S. (2003). Reflections on past behavior: A self-report index of habit strength. *Journal of Applied Social Psychology, 33*(6), 1313-1330. doi: 10.1111/j.1559-1816.2003.tb01951.x
- Verplanken, B., Walker, I., Davis, A., & Jurasek, M. (2008). Context change and travel mode choice: Combining the habit discontinuity and self-activation hypotheses. *Journal of Environmental Psychology, 28*(2), 121-127. doi: 10.1016/j.jenvp.2007.10.005



- Wallerstein, N., & Sanchez-Merki, V. (1994). Freirian praxis in health education: research results from an adolescent prevention program. *Health Education Research, 9*(1), 105-118.
- Walsh, D. C., Rudd, R. E., Moeykens, B. A., & Moloney, T. W. (1993). Social marketing for public health. *Health Affairs, 12*(2), 104-119.
- Wang, Y. C., McPherson, K., Marsh, T., Gortmaker, S. L., & Brown, M. (2011). Health and economic burden of the projected obesity trends in the USA and the UK. *The Lancet, 378*(9793), 815-825.
- Webb, T. L., Joseph, J., Yardley, L., & Michie, S. (2010). Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *Journal of medical Internet research, 12*(1).
- Weinstein, N. D. (1988). The Precaution Adoption Process. *Health Psychology, 7*(4), 355-386. doi: 10.1037//0278-6133.7.4.355
- Weinstein, N. D., & Sandman, P. M. (1992). A model of the precaution adoption process - evidence from home radon testing *Health Psychology, 11*(3), 170-180. doi: 10.1037/0278-6133.11.3.170
- West, R., & Brown, J. (2013). *Theory of addiction*: John Wiley & Sons.
- Westaby, J. D. (2005). Behavioral reasoning theory: Identifying new linkages underlying intentions and behavior. *Organizational Behavior and Human Decision Processes, 98*(2), 97-120.
- Wight, D., Abraham, C., & Scott, S. (1998). Towards a psycho-social theoretical framework for sexual health promotion. *Health Education Research, 13*(3), 317-330.
- Williams, G. C., Grow, V. M., Freedman, Z. R., Ryan, R. M., & Deci, E. L. (1996). Motivational predictors of weight loss and weight-loss maintenance. *Journal of Personality and Social Psychology, 70*(1), 115.
- Wilson, S., Cunningham-Burley, S., Bancroft, A., Backett-Milburn, K., & Masters, H. (2007). Young people, biographical narratives and the life grid: young people's accounts of parental substance use. *Qualitative Research, 7*(1), 135-151. doi: 10.1177/1468794107071427
- Wing, R. R., & Hill, J. O. (2001). Successful weight loss maintenance. *Annual review of nutrition, 21*(1), 323-341.
- Wing, R. R., & Phelan, S. (2005). Long-term weight loss maintenance. *The American journal of clinical nutrition, 82*(1), 222S-225S.

- Wing, R. R., Tate, D. F., Gorin, A. A., Raynor, H. A., & Fava, J. L. (2006). A self-regulation program for maintenance of weight loss. *New England Journal of Medicine*, 355(15), 1563-1571.
- Witkiewitz, K., & Marlatt, G. A. (2004). Relapse prevention for alcohol and drug problems - That was Zen, this is Tao. *American Psychologist*, 59(4), 224-235. doi: 10.1037/0003-066x.59.4.224
- Witte, K. (1992). Putting the fear back into fear appeals: The extended parallel process model. *Communications Monographs*, 59(4), 329-349.
- World Health Organization. (2015a). *Country profiles on nutrition, physical activity and obesity in the 53 WHO European Region Member States*. Copenhagen, Denmark: Retrieved from <http://www.euro.who.int/en/publications/abstracts/country-profiles-on-nutrition,-physical-activity-and-obesity-in-the-53-who-european-region-member-states.-methodology-and-summary>.
- World Health Organization (Producer). (2015b). *Global Recommendations on Physical Activity for Health* Retrieved from [http://www.who.int/dietphysicalactivity/factsheet\\_recommendations/en/](http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/)
- World Health Organization. (2015c). *Global Strategy on Diet, Physical Activity and Health*
- World Health Organization. (2015d). *Obesity and overweight. Fact sheet N°311*. Retrieved from <http://www.who.int/mediacentre/factsheets/fs311/en/>.
- Young, L., & Barrett, H. (2001). Adapting visual methods: action research with Kampala street children. *Area*, 33(2), 141-152.
- Yusof, A. F., & Iahad, N. A. (2012). Review on online and mobile weight loss management system for overcoming obesity. *Computer & Information Science (ICCIS)*, 1, 198-203.