Innovative approaches to treat overweight and obesity in adults: An investigation of a commercial web-based weight loss program

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Statement of originality

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying subject to the provisions of the Copyright Act 1968.

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I hereby certify that this thesis is in the form of a series of published papers of which I am a joint author. I have included as part of my thesis a written statement from each co-author, endorsed by the Faculty Assistant Dean (Research Training), attesting to my contribution to the joint publications.

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Conflict of Interest

Melinda Neve received a postgraduate scholarship top-up from SP Health Co Pty Ltd. There was in-kind support from SP Health Co in terms of provision of data but they had no role in the: design of the studies; analysis of data; writing of this thesis or the manuscripts it contains; or decision to submit the manuscripts for publication. SP Health collected some of the data. They reviewed each manuscript prior to submission, but not this thesis.

Publications and presentations arising from this thesis

Manuscripts in peer-reviewed journals: Published

1. Neve MJ, Collins CE, Morgan PJ. Drop-out, non-usage attrition, and pre-treatment predictors of non-usage attrition in a commercial web-based weight loss program. Journal of Medical Internet Research. 2010;12(4):e69.
2. Neve MJ, Morgan PJ, Collins CE. Participant characteristics and reach of a commercial web-based weight loss program. Nutrition & Dietetics. 2010;67(4):267-74.
3. Neve M, Morgan PJ, Jones PR, Collins CE. 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. 2010;11(4):306-21.
4. Collins CE, Morgan PJ, Jones P, Fletcher K, Martin K, Aguiar EJ, Lucas A, Neve M, McElduff P, Callister R. Evaluation of a commercial web-based weight loss and weight loss maintenance program in overweight and obese adults: a randomised controlled trial. BMC Public Health. 2010;10:669

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2. Neve MJ, Truby T, Collins CE, Morgan PJ, Davies PS, Callister R. Cross-sectional comparison of energy intake estimated by a web-based food diary to total energy expenditure measured by the doubly labelled water method in overweight and obese women. Journal of the American Dietetic Association (Submitted 6th July 2011)

Conference abstracts: Published in peer-review journals

1. Neve MJ, Morgan PJ, McElduff P, Collins CE. Is website use associated with weight loss in a commercial web-based weight loss program? 20th Annual Scientific Meeting, Australian and New Zealand Obesity Society, October 2010,

Sydney, Australia. Obesity Research and Clinical Practice 2010; 4 (S1):S2 (Poster presentation).

2. Neve MJ, Collins CE, McElduff P, Morgan PJ. Weight change among participants who subscribe to a commercial web-based weight loss program for 1 year. 20th Annual Scientific Meeting, Australian and New Zealand Obesity Society, October 2010, Sydney, Australia. Obesity Research and Clinical Practice 2010;4(S1):S3 (Poster presentation).
3. Collins CE, Neve MJ, Morgan PJ, McElduff P. Weight loss outcomes for over 10,000 participants in a commercial 12-week web-based program. 11th International Congress of Obesity, July 2010, Stockholm, Sweden. Obesity Reviews 2010;11(11):822 (Poster presentation).
4. Neve MJ, Morgan PJ, Collins CE. Web-based weight loss: How can the internet support dietitians to treat overweight and obese clients? 28th National Dietitians Association of Australia Conference May 2010. Melbourne, Australia. Nutrition & Dietetics 2010;67(S1):S4 (Oral presentation).
5. Neve MJ, Collins CE, Morgan PJ. Predictors of retention rates in a 12-week commercial web-based weight loss program. Nutrition Society of Australia & Nutrition Society of New Zealand Joint 2009 ASM December 2009, Newcastle, Australia. Asia Pacific Journal of Clinical Nutrition 2009;18(S3):S40 (Oral presentation).
6. Neve MJ, Morgan PJ, Jones P, Collins CE. Effectiveness of web-based interventions in achieving weight loss and weight maintenance. Nutrition Society of Australia ASM, December 2008, Adelaide, Australia. Asia Pacific Journal of Clinical Nutrition 2008;17(S3):S67(Oral presentation).

Conference abstracts: Published in conference proceedings

1. Neve MJ, Morgan PJ, Collins CE. Weight loss in the real word: outcomes of a commercial web-based weight loss program. Australian and New Zealand Obesity Society ASM, Melbourne, October 2009. Meeting Proceedings and Abstract Book available at: http://www.asso.org.au/freestyler/gui/files//ANZOS%202009%20ASM%20proceedings%20book.pdf (Oral presentation).
2. Neve MJ, Collins CE, Callister R, Morgan PJ. Validity of energy intake obtained from a web-based food diary before and after a web-based weight loss program. International Conference of Diet and Activity Methods, June 2009, Washington DC, USA. Program and Abstracts Book available at: http://www.icdam.org/ICDAM_Program_Abstracts_Book.pdf (Poster presentation).

3. Neve MJ, Morgan PJ, Collins CE. Who enrols in a commercially available web-based weight loss program? Australian and New Zealand Obesity Society ASM, Brisbane, Queensland, November 2008. Proceedings of the Australian Health and Medical Research Congress 2008 (Oral presentation).
4. Neve MJ, Colllins CE, Morgan PJ. Behavioural factors associated with long-term weight loss success in a commercial web-based weight loss program. 2011 Annual Meeting of the International Society for Behavioural Nutrition and Physical Activity. June 2011. Melbourne, Australia (Oral presentation).
5. Neve MJ, Collins CE, Truby H, Morgan PJ, Davies PSW, Callister R. Accuracy of self-reported energy intake using a web-based food diary. 2011 Annual Meeting of the International Society for Behavioural Nutrition and Physical Activity. June 2011. Melbourne, Australia (Poster presentation).

Other presentations

1. Neve MJ. Female members of a commercial web-based weight loss program – how do they differ to males, and what are the potential implications for treatment? Meeting of the Newcastle Branch of the Nutrition Society of Australia, Newcastle, Australia, August 2010 (Invited).
2. Neve MJ. The Biggest Loser Club: The potential public health impact of a commercial web-based weight program. The University of Newcastle, Faculty of Health, 10 of the Best Research Higher Degree Showcase, September 2010.

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List of abbreviations

ARIA	Accessibility/Remoteness Index of Australia
BIA	Bioelectrical impedance analysis
BMI	Body mass index
CI	Confidence interval
cm	Centimetre
COPD	Chronic obstructive pulmonary disease
CV	Coefficient of variation
DLW	Doubly labelled water
EI	Energy intake
GLMM	Generalised linear mixed model
HR	Hazard ratio
IPAQ	International Physical Activity Questionnaire
IQR	Interquartile range
IRSAD	Index of Relative Socioeconomic Advantage and Disadvantage
JBI	Joanna Briggs Institute
Kg	Kilogram
LOCF	Last observation carried forward
m	Metre
NUTTAB	Nutrient Data Tables for use in Australia
NWCR	National Weight Control Registry
PDA	Personal digital assistant
RCT	Randomised controlled trial
SD	Standard deviation
SMD	Standardised mean difference
SMS	Short message service
TBW	Total body water
TEE	Total energy expenditure

WHO	World Health Organisation
WMD	Weighted mean difference

Abstract

Overweight and obesity are a major cause of preventable death and morbidity; furthermore the associated health care costs are substantial. Given the growing obesity epidemic, effective behavioural interventions are urgently required to achieve initial weight loss and maintenance of lost weight long-term. Interventions also need to engage large numbers of overweight and obese individuals in a cost-effective manner. Internet or web-based behavioural interventions have emerged in recent years as an innovative medium for providing treatment. The primary purpose of this thesis is to establish the value of a commercial web-based weight loss program as a treatment option for overweight and obese adults. Four research studies were undertaken to meet this aim.

A systematic review of the available literature determined the effectiveness of web-based interventions on weight change. Meta-analyses provided promising, but not convincing, evidence that firstly, web-based interventions with enhanced features can achieve greater weight loss than those with education components alone and secondly, that web-based interventions to achieve maintenance of lost weight result in less weight regain compared to control groups without an active intervention.

A cohort study tracked usual participants (n=11341) of a commercial web-based weight loss program for up to 52-weeks. The program reached a large number of overweight and obese individuals at risk of obesity-related co-morbidities, due to their poor eating and exercise habits at enrolment. Participants on average achieved clinically important and statistically significant weight loss after 12- and 52-weeks membership periods. The study also found that use of website features was positively correlated with weight loss. However, use of the web-based program by participants was relatively low and highly variable. Participants aged 45 to 65 years, and with positive eating and physical activity habits at enrolment were less likely to stop using the program.

Participants of the cohort study, who agreed to be contacted for research purposes (n=5625), were followed-up 15-months post initial enrolment and invited to complete an online survey. The survey found that approximately one third of respondents reported ≥5% weight loss since enrolment, and that weight loss increased significantly with length of membership to the commercial program. Significant behavioural predictors of success (≥5% weight loss) included regular self-monitoring of weight, not skipping meals, not keeping snack foods in the house and eating takeaway foods infrequently.

A small sub-study evaluated the accuracy of energy intake estimated by a web-based food diary compared to total energy expenditure measured using doubly labelled water in weight stable overweight and obese women (n=9). Self-reported energy intake obtained from a web-based food diary was under-reported by 20% on average, which is consistent with other published dietary intake methods.

In conclusion, the study findings presented in this thesis provide evidence to support the use of web-based interventions as a treatment medium for overweight and obese adults, due to their ability to reach a large number of 'at-risk' individuals, ability to capture accurate energy intake data and potential to achieve clinically important weight loss. However, the findings also highlight that participant's engagement with web-based interventions is an area that needs to be addressed as a key strategy to improve weight-related outcomes. The results have implications for overweight and obese individuals, clinicians and web-based program developers, and key recommendations for ongoing research into web-based weight management interventions are provided.

Chapter One: Introduction

1.1 Background and context

1.1.1 Overweight and obesity: The health problem

Throughout the world, 1.6 billion people aged 15 years or over are overweight and 400 million are obese (1). By 2015, the World Health Organisation (WHO) has estimated that this will increase to 2.3 billion overweight and 700 million obese individuals (1). The most recent estimates derived from measured weight data collected as part of Australia's National Health Survey (2007-08) revealed that 37% of Australian adults are overweight and 25% are obese (2). The highest prevalence of overweight and obesity is among those aged 65 to 74 years of age (75%), and overall more males are overweight and obese (68%) than females (55%) (2). The prevalence of overweight and obesity among Australian adults is steadily rising. From 1995 to 2007-08, the combined prevalence increased by 5%. During this time the prevalence of overweight remained steady, but the prevalence of obesity increased by over 5% (2). By 2025, it is anticipated that 6.9 million Australians will be obese (3).

The health consequences of overweight and obesity are well documented. In 2004, overweight and obesity was the fifth highest risk factor contributing to death, causing 5% of deaths worldwide (4). Moreover, in middle- and high-income countries, it was the third leading risk factor, causing 7% and 8% of deaths respectively (4). As illustrated in Table 1.1, the risk of mortality as well as morbidity from diseases including ischemic heart disease, stroke, diabetes, chronic obstructive pulmonary disease (COPD), and several cancers, increases significantly with each body mass index (BMI) unit increase above 22 kilogram (kg)/metre $(m)^2$ (5). Psychological complications such as depression, anxiety and decreased quality of life are also prevalent among overweight and obese individuals (6, 7). In Australia, overweight and obesity is the third highest contributor to the total burden of disease (8) and approximately 24% of type 2 diabetes mellitus, 21% of cardiovascular disease, 25% of osteoarthritis and 21% of selected cancer cases are attributable to obesity (3).

The increasing prevalence of overweight and obesity and associated health consequences have also resulted in huge increases in the economic costs to society. In many developed countries, 2% to 6% of total health care costs are due to obesity (7). In 2008, it was estimated that the financial cost of obesity in Australia was $AU8.3 billion, of which 44% ($AU3.6 billion) were productivity costs, 24% ($AU2.0 billion) health system costs and 23% ($AU1.9 billion) carer costs. When indirect costs were included in the estimates, the total financial cost reached $AU58.2 billion. This included

an additional $AU803 million from indirect costs, as well as $AU49.9 billion due to loss of wellbeing (3). Obese individuals (29%) or their family and friends (19%), as well as the government (34.3%) endure the majority of financial costs. Importantly, these estimates only consider the impact of obesity and not overweight. Therefore, the actual cost of overweight and obesity combined is much more.

Table 1.1 Estimated relative risk of disease per unit of BMI above 22 kg/m^2

Disease	Relative risk per BMI unit above 22		Impact of age/smoking
	Male	Female	
All-cause mortality	1.07	1.03	Reduction in risk from age 50
Ischemic heart disease	1.06	1.10	Reduction in risk from age 65 Increased risk with smoking
Stroke	1.04	1.04	Reduction in risk from age 65
Diabetes	1.18	1.22	Reduction in risk from age 60
COPD	1.00	1.00	
Lung cancer	0.97	0.98	
Breast cancer	1.00	1.00	1.02 from age 50
Oesophageal cancer	1.04	1.02	Reduction in risk from age 45
Renal cancer	1.05	1.05	
Gallbladder cancer	1.02	1.06	Reduction in risk from age 45 for females Increase in risk from age 45 for males
Womb cancer		1.10	

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A large cohort study conducted in Australia (AusDiab), calculated the cost of overweight and obesity at the individual level in 1999-2000 and 2004-05. The annual direct health care costs were higher for overweight ($AU2110) and obese ($AU2540) individuals, compared to healthy weight individuals ($AU1710) (9). Furthermore, from 1999-2000 to 2004-05, the highest annual direct health care costs were among those who remained obese ($AU2853) or progressed from being overweight to obese ($AU2648) (9), which is the current trend for the Australian population.

Therefore, due to the increasing prevalence, associated adverse health outcomes, and enormous economic costs, overweight and obesity is a priority health problem, requiring support from health, research, and government bodies worldwide. Overweight and obesity is supported by WHO's Global Strategy on Diet, Physical Activity and Health (10), as well as the 2008-13 Action Plan for the Global Strategy for the Prevention and Control of Non-Communicable Diseases (11). Australia's National Healthy Strategy (Australia: the Healthiest Country by 2020) also supports overweight and obesity as a priority health issue (12). The focus of this strategy is the prevention of unhealthy weight gain (13). This encompasses obesity prevention, weight loss and maintenance, as well as the management of weight-related risk factors (13).

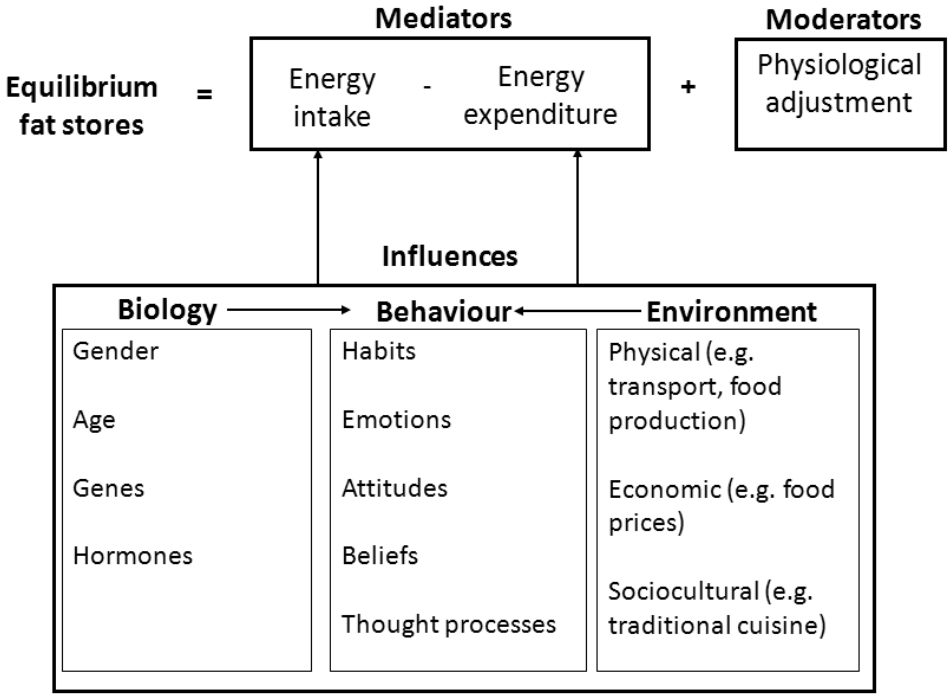
The attainment and maintenance of moderate weight loss (up to 10% of initial weight) by overweight and obese adults, can lead to substantial improvement or even

prevention of weight-related co-morbidities. This includes risk factors for type 2 diabetes mellitus and cardiovascular disease, such as impaired glucose tolerance, blood lipids and blood pressure (6, 7). For example, the U.S. Diabetes Prevention Program found that overweight and obese adults with pre-diabetes who took part in a behavioural intervention for an average of 2.8 years and who on average lost 5.8kg, decreased their risk of type 2 diabetes mellitus by 58% (14). Therefore, interventions capable of achieving even modest weight loss with long-term maintenance of the weight loss have the potential to make a substantial public health impact in terms of the health and economic consequences of overweight and obesity.

1.1.2 Overweight and obesity: Possible solution

Weight gain results when an individual's energy intake (EI) surpasses their total energy expenditure (TEE). If this excess continues for a significant time, weight gain will progress and the individual will be classified as overweight (BMI ≥25-<30) or eventually obese (BMI ≥30) (7). An adult's EI is determined from the food and drink consumed, whilst TEE incorporates their basal metabolic rate, activity-related energy expenditure and thermogenesis (7). These factors have been described as the mediators of weight maintenance. However, weight maintenance is complicated by many behavioural, biological and environmental factors (7, 15) (Figure 1.1). The focus of efforts to prevent unhealthy weight gain is the modifiable influences on energy balance, particularly behavioural factors.

Behavioural interventions assume that positive changes to dietary behaviour and physical activity habits will result in weight loss or prevent further weight gain, and that behaviours are modifiable. Behavioural interventions traditionally involve weekly group-based sessions for 3- to 6-months, most often conducted by dietitians, psychologists, exercise physiologists and/or other health professionals (16). The interventions employ key strategies, such as self-monitoring, stimulus control, stress management, problem solving, contingency management, cognitive restructuring, and social support (Table 1. 2). Behavioural interventions success in achieving weight loss and/or weight loss maintenance is highly variable, but when successful, participants achieve an average 5% to 10% weight reduction (17, 18). However, maintenance of lost weight is a problem, with greater than 50% of participants returning to their baseline weight within 5-years post-treatment (17, 18). Therefore, intervention strategies with the ability to achieve and maintain weight loss are still required.



Adapted from Egger G and Swinburn B (2007) (15)

Figure 1.1 Ecological paradigm for understanding overweight and obesity

Given the growing obesity epidemic, effective behavioural interventions are not only required to achieve weight loss, as well as long-term weight loss maintenance, but they must also engage a large number of overweight and obese individuals in a cost-effective manner (19).The ability of traditional treatment mediums to reach overweight and obese adults has not been well described (20). However, the substantial resources required to provide obesity treatment to the billions of people using traditional treatment approaches (e.g. face-to-face individual or group-based sessions) is not viable. Therefore, we require innovative approaches to treatment provision, capable of reaching this large and expanding target group in a resource efficient manner. Internet or web-based behavioural interventions have emerged in recent years as a potential medium for providing treatment.

The Internet has the capability to provide interactive and tailored support to overweight and obese adults, while still incorporating fundamental behavioural weight management strategies (Table 1.2). They also have the potential to reach a large number of people, given the exponential growth in Internet access in the last decade (21). However, we currently have limited understanding of what type of individuals web-based weight management interventions appeal to (Section 2.2.4). There is also some

evidence from randomised controlled trials (RCT) to suggest that web-based interventions can achieve modest weight loss, however they are still an under-evaluated treatment medium (Section 2.2.2). Participants' use of web-based weight management interventions appears to be a key factor associated with success, but their ability to retain and engage participants is currently inadequate (Section 2.2.3). Therefore, there is a need to confirm the ability of web-based weight management interventions to achieve significant weight loss and weight loss maintenance, as well as evaluate attrition rates and website use. A better understanding of the types of individuals who participate in web-based interventions, and of this group, who actively participates and completes the intervention is also required.

Table 1.2 Fundamental behavioural weight management strategies

Strategy	Description
Self-monitoring (6, 22)	This involves individuals recording their food intake, physical activity, and weight. The purpose is to raise awareness of poor behaviours requiring modification to achieve weight loss/maintenance.
Stimulus control (6, 22)	Aims to identify precursors to poor eating and activity habits, and develop strategies to overcome. Not keeping high sugar/fat foods in the home and avoidance of situations where overeating may arise, are some examples of stimulus control strategies.
Stress management (22)	Many overweight and obese individual consume food due to stress or other emotions. Therefore, employment of strategies to overcome these behaviours is required. Mediation and relaxation strategies may be effective.
Problem solving (6, 22)	This involves individuals rectifying eating and physical activity problem areas. Problem solving should work through the cycle of: defining the problem; developing solutions to the problem; choosing the most appropriate solution; implementing the new behaviour and re-evaluation/reflection to determine if the changes were successful.
Contingency management (6, 22)	This involves individuals receiving a reward (e.g. verbal, money) for appropriate actions related to their weight management (e.g. meeting exercise goals). Service providers may provide the rewards, or the participants may reward themselves.
Cognitive restructuring (6, 22)	This involves individuals identifying, confronting and overcoming negative thoughts associated with their weight loss journey/ weight gain.
Social support (6, 22)	This involves support, motivation and reinforcement from social networks (e.g. family, friends, partners, work colleagues, other intervention participants)
Relapse prevention (6, 22)	This involves training individuals to develop skills that help overcome problems/setbacks to avoid weight regain.

Furthermore, most scientifically evaluated web-based weight management programs are not available to the public. Commercial web-based weight loss program are the most accessible web-based interventions for consumers (23), but only one has been scientifically evaluated, in two RCTs (24, 25). Therefore, little is known about the overall effectiveness of commercial web-based weight loss programs in achieving weight loss or maintenance, as well as their ability to recruit, retain, and engage their target group. There is also limited understanding of these factors for fee-paying

members of commercial programs, as most studies are commonly conducted as RCTs with convenience samples of participants (Section 2.3).

Finally, web-based interventions also provide a unique opportunity, whereby data collection can occur as part of the intervention process. Such self-reported measures are convenient, economical, simple to administer and can reach a significant number of participants. However, the validity of data collected via the Internet is not well established. This includes data collected as part of a weight management intervention, such as assessment of dietary intake (Section 2.4).

1.2 Research aims and hypotheses

Overall, the primary purpose of this thesis is to establish the value of a commercial web-based weight loss program as a treatment option for overweight and obese adults. More specifically, the aims of this thesis are:

1. To systematically review available literature to determine the effectiveness of web-based interventions on weight change, and determine what components of web-based interventions are associated with greater weight change and lower attrition rates.
2. To describe the characteristics of participants who enrolled in a commercial web-based weight loss program, and to assess the potential reach of the program.
3. To describe the weight loss achieved by participants of a commercial web-based weight loss program, in a cohort of enrolees who subscribed to the program for 12- or 52-weeks.
4. To describe website use and attrition rates of a commercial web-based weight loss program after 12- and 52-weeks membership.
5. To assess the relationship between weight change, and use of a commercial web-based weight loss program in a cohort of enrolees who subscribed to the program for 12- or 52-weeks.
6. To describe pre-treatment predictors of attrition in a commercial web-based weight loss program after 12- and 52-weeks membership.
7. To follow-up a cohort of enrolees of a commercial web-based weight loss program 15-months post-enrolment, and describe the weight change achieved.
8. To determine which behavioural factors are associated with successful weight loss 15-months post-enrolment in a commercial web-based weight loss program.

9. To evaluate how accurate EI estimated by a web-based food diary, by comparison with TEE obtained by the gold standard doubly labelled water (DLW) technique in overweight and obese women.

The subsequent hypotheses are:

1. Participants who enrol in a commercial web-based weight loss program will be similar to other commercial and web-based weight management programs (i.e. predominantly female, middle-aged, higher socio-economic status).
2. Participants will achieve a mean weight change similar to the weight loss reported by systematic reviews of behavioural interventions (~5% to10%) during their 12- and 52- week subscription to the commercial web-based weight loss program.
3. Participants' use of the commercial web-based weight loss program features will decline from baseline to 52-weeks.
4. Greater use of the commercial web-based weight loss program will be associated with greater weight loss, for 12- and 52-week subscribers
5. Pre-treatment characteristics will predict attrition in a commercial web-based weight loss program after 12- and 52-weeks membership.
6. Participants mean weight change will be lower (<5%) at 15-months post-enrolment in the commercial web-based weight loss program, due to weight regain following the completion of the intervention.
7. Successful weight loss (≥5%) at 15-months post-enrolment will be associated with more frequent self-monitoring of weight, food, and physical activity, as well as positive eating and physical activity habits.
8. Participants will under-report their EI using a web-based food diary, within the range of other food diaries (4% to 47%).

1.3 Thesis structure and study design

1.3.1 Overview

The thesis begins with a review of the literature (Chapter 2). The background, methods, results, discussion of finding and implications of the research conducted for this thesis are then presented as a series of six research papers (Chapter 3 to 8). The papers present work from a body of research made up of four key components: a systematic review (Section 1.3.2), a cohort study (Section 1.3.3), a long-term follow-up of a sub-group of cohort members at 15-months post-enrolment (Section 1.3.4) and a validation

sub-study (Section 1.3.5). A brief overview of each component is provided below, including its relationship with the included research papers. An overall discussion of the findings from the body of research, and the implications for research and practice are provided as the final chapter of the thesis (Chapter 9).

1.3.2 Systematic review

A comprehensive systematic review of the literature was undertaken to identify the effectiveness of web-based interventions on weight change and what components of web-based interventions are associated with greater weight change and lower attrition rates (research aim 1). A pre-defined protocol, peer-reviewed by the Joanna Briggs Institute (JBI) (http://www.joannabriggs.edu.au/protocols/Protocol220.pdf) was used to conduct the review. Ten databases were searched for RCTs published from 1995 to April 2008. To be included in the review the participants must have been overweight and/or obese adults, at least one study arm must have included a web-based interventions with the primary aim of achieving weight loss or weight loss maintenance, and an overweight/obesity related outcome must have been reported (e.g. weight, BMI change). Comprehensive data extraction was undertaken using a standardised data extraction tool. The tool included specific details about the intervention, participants, study methods and outcomes of significance. All included studies were assessed for methodological quality using a standardised critical appraisal form. The detailed methods and results pertaining to the objectives of this review have been published in one paper (Chapter 2).

1.3.3 Cohort study

A cohort of fee-paying participants of a commercial web-based weight loss program was tracked for up to 52-weeks post-enrolment. SP Health Co Pty Ltd (Sydney, Australia) developed the web-based weight loss platform that is commercially available as The Biggest Loser Club, Australia (www.biggestloserclub.com.au). The program is referred to as the ‘commercial web-based weight loss program’, ‘The Biggest Loser Club’, or ‘the SP Health Weight Loss Platform’ hereafter.

Participants enrolled in the program from August 15th 2007 to May 31st 2008. To enrol in the program participant had to be aged 18 to 75 years and have a BMI ≥22. The BMI requirements were set by SP Health Co. Inclusion of participants within the health weight range (BMI 22 to 25) allowed individuals who wished to prevent further weight gain to enrol. Participants purchased a subscription plan at enrolment. The subscription plans were of 4-, 12-, 16-, or 52-weeks duration and were paid for either prospectively at enrolment or by monthly instalments. Participants may have signed up for

consecutive subscription plans. In 2007-08 the cost of the program ranged from $AU16.50 to AU$79.95 per month. The cost per month to the participant was lower if they subscribed for longer and/or paid up front. To be included in the cohort study, participants must have paid for their initial subscription to the program, meaning that participants who signed up to the program using free trials were excluded.

The program was established as a 12-week self-directed weight loss program, but participants could chose to subscribe to the program for longer to assist with further weight loss and/or maintenance of lost weight. The online program incorporated evidence based weight management strategies (Appendix 1) and aligned with key elements of social cognitive theory (9). The web-based program involved participants setting a goal weight. They were then encouraged to work towards this target in 'mini goals' (e.g. 5kg or 5%) and monitor their weight loss by entering their weight or other body measurements into the website or report their weight via short message service (SMS). If weight and/or other body measurements were reported, participants could view graphs and charts detailing their progress over time (e.g. total weight change). Participants were encouraged to monitor their weight once per week and received weekly reminders to weigh-in via email or SMS during the initial 12-week program. Participants could also set daily EI goals, which were based on their weight, height, and physical activity level. The goal could be set to facilitate a weight loss of 0.5 to 1kg per week or to maintain their current weight. Participants could self-monitor their dietary (food/beverage) intake and exercise using an online diary, which calculated their EI and TEE based on the data entered. Participants also received online information in the form of weekly tutorials, fact sheets, meal and exercise plans and weekly challenges during the initial 12-week program. After 12-weeks participants continued to receive weekly tutorials only. Participants were prompted to access the online information via a weekly email. Social support was also available for participants via a discussion board to communicate with other members.

Data for the cohort study were collected by the program proprietor (SP Health Co.), and provided to the researchers in de-identifiable form. Participants consented at enrolment for their data to be provided to researchers. Ethics approval was obtained from the University of Newcastle Human Research Ethics Committee (H-2008-280). Data retrieved and provided for analysis included:

- Enrolment survey responses: anthropometrics (weight, height and waist circumference), demographics (age, gender, ethnicity and postcode), reasons for trying to lose weight and current dietary and physical activity behaviours (number of days exercised, eating habits and reasons for eating) (Appendix 2).

- Subscription data (date of enrolment, date membership ceased and subscription plans held).
- Website use (date of: log-in, online food and exercise diary entries and posts to the discussion forum).
- Weigh-in records (date of weigh-in and weight recorded).

Five of the research aims were addressed by this study, and the results are presented in three papers (Chapter 4 to 6) and additional results as an appendix (Appendix 3). Table 1.3 outlines how each research aim was addressed by the study, by outlining the data that was utilised and the participants that were included in each analysis.

Table 1.3 Overview of how the thesis research aim(s) are addressed by the cohort study

Research aims	Data	Eligible participants	Thesis chapter
2. To describe the characteristics of participants, and to assess the potential reach of the program.	Enrolment survey responses.	All cohort members (n=11341).	3
3. To describe the weight loss achieved by participants of a commercial web-based weight loss program, in a cohort of enrolees who subscribed to the program for 12- or 52-weeks.	Enrolment survey anthropometrics and weigh-in records.	Cohort members who subscribed for 12- or 52-weeks (n=6943, 2656).	4
4. To describe website use and attrition rates of a commercial web-based weight loss program after 12- and 52-weeks membership.	Subscription data and website use.	Cohort members who subscribed for 12- or 52-weeks (n=6943, 2656).	4 & 5
5. To assess the relationship between weight change, and use of a commercial web-based weight loss program in a cohort of enrolees who subscribed to the program for 12- or 52-weeks.	Enrolment survey anthropometrics weigh-in records and website use.	Cohort members who subscribed for 12- or 52-weeks (n=6943, 2656).	4
6. To describe pre-treatment predictors of attrition in a commercial web-based weight loss program after 12- and 52-weeks membership.	Enrolment survey, subscription data and website use.	Cohort members who subscribed for 12- or 52-weeks (n=6943, 2656).	5 and Appendix 3

1.3.4 Long-term follow-up study

Cohort participants who agreed at enrolment to being contacted to participate in further research were invited to complete an online survey. Eligible participants were invited via email to participate by SP Health Co., approximately 15-months post their enrolment date. The online survey included 32 questions. The aim of the survey was to describe the weight change achieved by participants 15-months post-enrolment, and

determine which behavioural factors are associated with successful weight loss (≥5%) at this time point (research aim 7 and 8). Data related to the participant's weight status, eating and activity behaviours, weight control practices and intervention satisfaction (Appendix 4) were collected. Data collected as part of the cohort study (i.e. enrolment survey responses) were also used (Section 1.3.3). Ethics approval was obtained from the University of Newcastle Human Research Ethics Committee (H-2008-280). The detailed methods and results of this study are presented in one paper (Chapter Seven).

1.3.5 Validation sub-study

A cross-sectional validation study was undertaken in a small group of weight stable overweight and obese females (n=9). The study evaluated the accuracy of EI estimated by a web-based food diary in comparison to the gold standard method, the DLW technique (research aim 9). As previously outlined, the web-based food diary is a component of the commercial web-based weight loss program. To determine its accuracy, the average EI self-reported by participants from the web-based food diary over a 9-day period, was compared to TEE estimated using the DLW technique. Comparison of TEE to EI was made though assessment of absolute and percentage difference, and production of a Bland-Altman Plot to interpret agreement. Participants were identified as under-reporters of EI based on the 95% confidence limits of the expected EI: TEE of one. Ethics approval for the study was obtained from the University of Newcastle Human Research Ethics Committee (H-2008-01807). The detailed methods and results of this study are presented in one paper (Chapter 8).

Chapter Two: Literature review

2.1 Overview

Chapter 2 presents a comprehensive review of web-based interventions, as an innovative approach to developing and delivering behavioural interventions for the treatment of overweight and obesity (Section 2.2). This includes the potential of the Internet to deliver behavioural weight management interventions (Section 2.2.1), as well as their ability to achieve and maintain weight loss (Section 2.2.2), engage participants (Section 2.2.3) and reach their intended target group (Section 2.2.4). As the current predominant provider of web-based weight management interventions is the commercial sector, the evidence regarding the effectiveness of commercial weight management programs is also explored (Section 2.3). The final section of the literature review (Section 2.4) outlines the capabilities of the Internet in terms of assessing dietary intake. Figure 2.1 illustrates the content, structure and flow of the literature review.

2.2 Web-based weight management interventions

2.2.1 Capability of web-based weight management interventions

The Internet has the potential to deliver innovative behaviour change interventions (26). The type of multimedia experiences and activities that can be provided for clients exceeds most other mediums (27). The materials created as part of a website can be updated efficiently and in a timely manner, allowing the most recent evidence-based information to be available (26, 28). Web-based interventions also have the unique ability to adapt the content or media to meet the requirements of individuals or groups (e.g. gender, culture, age, learning styles) (26-28). This permits an individualised approach, similar to that of a face-to-face consultation (29). However, a recent review of health interventions delivered via the Internet found that current web-based interventions vary considerably in how they utilise the capabilities of the Internet (29). The web-based health interventions ranged from brief health assessments to tailored interventions including tools to develop self-regulatory skills, as well as educational content (29). Therefore, current web-based interventions include a diverse range of features, demonstrating the potential for growth and innovation in the future.

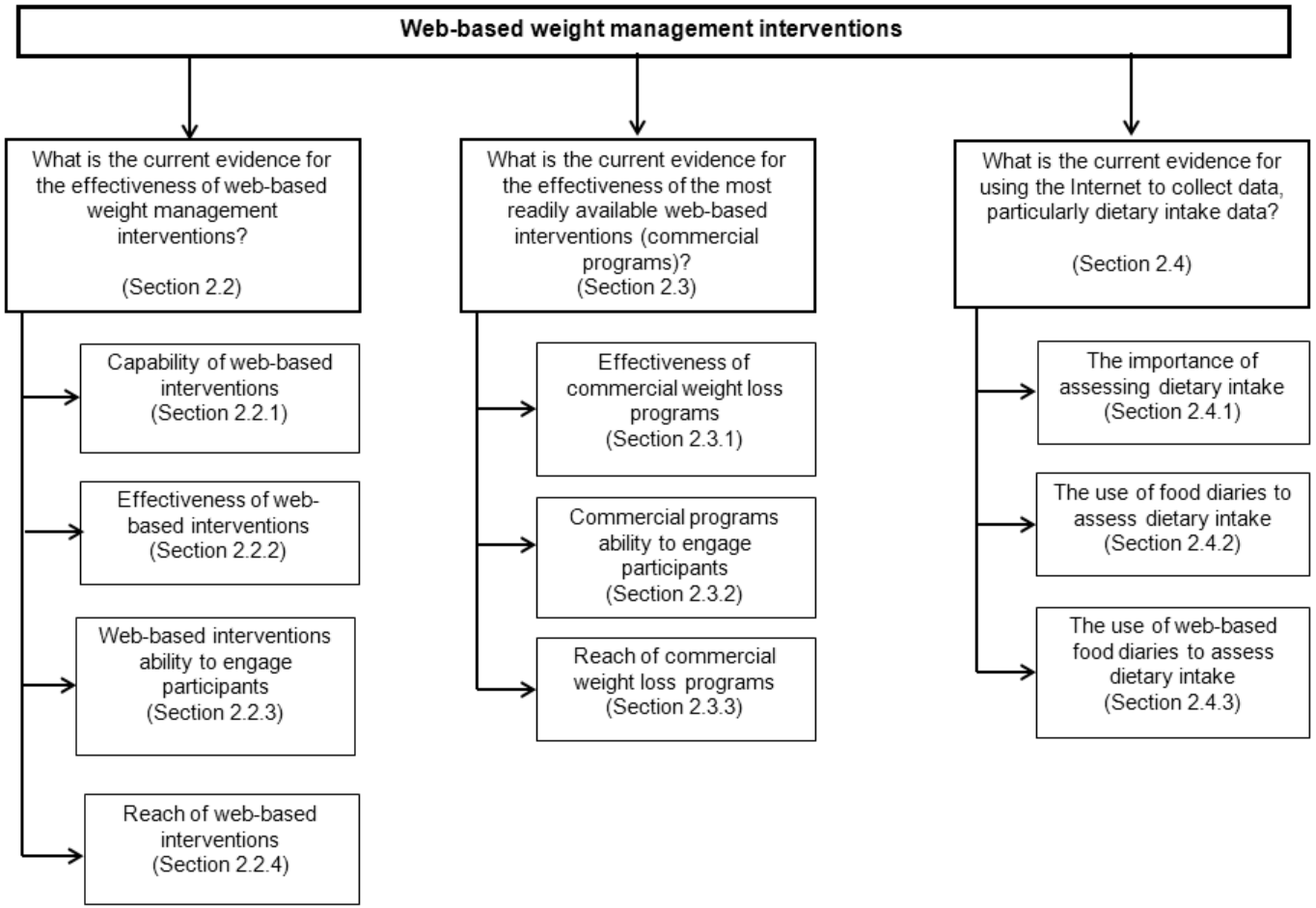


Figure 2.1 Content, structure and flow of the literature review

Web-based interventions aiming to achieve weight loss and/or weight loss maintenance typically provide similar strategies to traditional behavioural treatments, previously outlined (Table 1.2). Developing innovative ways to incorporate these strategies into web-based interventions is an ongoing challenge. Therefore, there are no established or evidence-based methods for provision of key behavioural strategies via the Internet. However, two systematic reviews (30, 31) were recently published that suggest key components of web-based weight management interventions (Table 2.1). The key components are: a theoretical framework; inclusion of self-monitoring, social support, feedback to participants and interactive components; an individually-tailored; and structured program. Both reviews acknowledged the development, evaluation and dissemination of web-based weight management interventions is only in its infancy (30, 31). Therefore, the web-based weight management interventions presented in the subsequent sections vary in their incorporation and/or provision of the key components.

Table 2.1 Key components of web-based weight management interventions

Component	Description
Theoretically based	Several behaviour change models have been utilised by web-based weight management interventions (e.g. Transtheoretical model, Social Cognitive Theory) (31).
Self-monitoring	Dynamic and engaging self-monitoring tools can be provided via the Internet, that are easy to use (30, 31).
Social support	Web-based social support, such as e-counselling, chat rooms, discussion forums, blogs, bulletin boards or e-mails are a key component of web-based weight management programs (30, 31). Real-time chats or meetings may be more effective in achieving social support than other online tools (30).
Feedback	Provision of tailored feedback to participants, which may be from a person, or automatically generated, is a key component of web-based weight management interventions (30, 31).
Structured program	Programs with a structure (e.g. expected number of lessons, self-monitoring, weigh-ins) may be more effective than unstructured/self-directed programs (30).
Individually tailored program	Programs that tailor the content/features provided to participants goals and/or behavioural/demographic characteristics may be more effective in achieving weight loss and treatment adherence (30).
Interactive components	Some or all program features are commonly interactive. Examples of interactive features include food and exercise diaries, homework assignments, quizzes, and weigh-ins with graphs (31).

2.2.2 Effectiveness of web-based weight management interventions

The overall effectiveness of web-based interventions to achieve health behaviour change is an area of increasing research interest. From 1999 to 2009, the number of studies published in PubMed related to web-based interventions increased by over 100 per year (Figure 2.2). Wantland *et al.* systematically reviewed web-based interventions aiming to achieve behaviour change compared to non-web-based interventions, published from 1996 to 2004 (32). They concluded that web-based interventions improve behavioural outcomes, but the results should be interpreted with caution due

to the high variability in study populations, intervention designs, as well as the effect sizes reported (32).

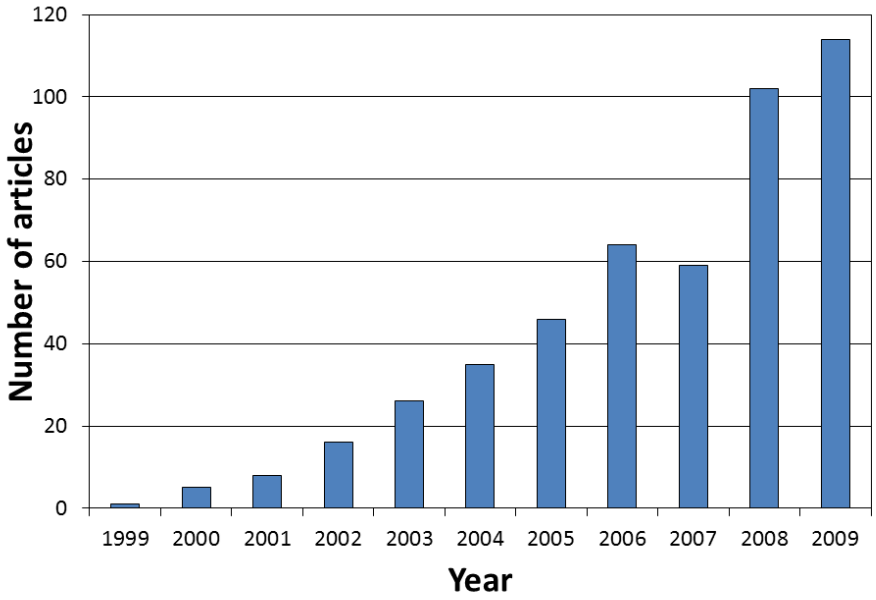


Figure 2.2 Number of articles listed on PubMed on 'web-based interventions' 1999 to 2009

Five reviews, published from 2006 to 2010, have evaluated the ability of web-based interventions to achieve weight loss and/or weight loss maintenance (27, 28, 33-35). They report inconsistent results (Table 2.2). Norman *et al.* found that less than half of the included studies reported significantly greater weight loss for eHealth interventions, compared to other treatment mediums (28). Comparably, Enwald and Huotari reported less than one third of included studies demonstrated greater improvements for Internet compared to control or traditional treatment medium groups for behavioural and physiological outcomes (34). Arem and Irwin found that the effectiveness of web-based interventions in achieving weight loss was inconsistent (<1kg to -4.9 kg) across studies, but suggested web-based weight loss maintenance interventions showed promise when they followed on from a traditional weight loss treatment, such as face-to-face group sessions (33). Alternatively, two other reviews, suggested that web-based interventions are as effective as other lifestyle intervention options (35), but that it is unclear whether web-based interventions are effective in achieving maintenance of weight loss (35).

Table 2.2 Chronological summary of web-based intervention review articles evaluating interventions for weight loss or maintenance

Study	Inclusion criteria	Reach	Efficacy	Drop-out attrition	Non-usage attrition	Suggestions for further research	Strengths and limitations
Weinstein 2006 (35)	*Inclusion criteria* ▪ RCT. ▪ Published 1995 to June 2005. ▪ WL/WLM int. ▪ Overweight/obese adults. ▪ The Internet as at least 1 mode of delivery. *Included studies* ▪ n=8 (5 WL, 3WLM).	▪ WL: three all or mainly females, two all or mainly males. ▪ Mean age range 30 to 62 yrs. ▪ White and well educated. ▪ WLM: Reach not described.	▪ WL: Most studies showed initial weight changes .similar to other int. ▪ WLM: Equivocal results.	▪ WL:0 to 34%. ▪ WLM: Data not presente d.	Not reported.	▪ Study representative populations. ▪ Study process measures (suitability and acceptability). ▪ Explore individually tailored programs.	*Strengths* ▪ Included WL and WLM. *Limitations* ▪ No critical appraisal. ▪ Limited search strategy (14 articles located). ▪ No definition of overweight/obesity given for inclusion. ▪ Inclusion of two studies questionable as all participants may not be overweight/obese.
Norman *et al*. 2007 (28)	*Inclusion criteria* ▪ RCT or quasi-experimental. ▪ Published 2000 to 2005. ▪ PA, DB or WL int. ▪ Adults and children. ▪ Electronic technology int. *Included studies* ▪ n=39. ▪ 13 PA, 16 DB and 20 WL.	'Mainly adult females'.	▪ PA: Six showed no differences between groups, 3 with positive results for eHealth int. ▪ DB: Five showed no differences between groups, 7 with positive results for eHealth int. ▪ WL: Six favoured eHealth for behaviour change. ▪ Four favoured eHealth for WL.	▪ PA: 10 ≤20%. ▪ DB: 9 ≤20%. ▪ WL: 11 ≤20%.	▪ 'Low dose and poor usage'. ▪ Most reported participant s used the website features less than ½ the expected amount. ▪ Log-in rates decrease d over time.	▪ Focused reviews with meta-analysis. ▪ Determine effectiveness and how/why int. are successful. ▪ Strategies to encourage participant usage required to ensure 'optimal dose'.	*Strengths* ▪ Comprehensive search strategy. ▪ Thorough appraisal. *Limitations* ▪ Results not divided into adults and children. ▪ Not specific to web-based interventions or weight management. ▪ All studies were included in review despite wide range in quality score (22 to 100%).

Study	Inclusion criteria	Reach	Efficacy	Drop-out attrition	Non-usage attrition	Suggestions for further research	Strengths and limitations
Saperstein *et al.* 2007 (27)	*Inclusion criteria* ▪ RCT ▪ WL int. ▪ Internet int. ▪ Adults. ▪ No WLM int. ▪ Time frame unclear published 2007. *Included studies* ▪ n=6.	Not reported	▪ Five demonstrated positive WL results using web-based programs. ▪ Individualised information achieved better results than education only websites.	Not reported.	Not reported.	▪ Determine reach and impact. ▪ Determine appropriate methods for dissemination of ints.	*Strengths* ▪ Reports only on web-based int. in adults. *Limitations* ▪ Not a systematic review. ▪ Searched three databases only. ▪ No critical appraisal.
Arem and Irwin 2010 (33)	*Inclusion criteria* ▪ RCT. ▪ Published 2001 to 2009. ▪ Adults. ▪ WL/WLM. ▪ Web-based program. *Included studies* ▪ n=9.	▪ Average age 35 to 54 yrs. ▪ 50 to 100% female. ▪ 50 to 95% Caucasian.	▪ Int. inconsistent effect on weight (<1 to -4.9kg WL). ▪ Int. with dynamic and tailored features following traditional WL int. promising for WLM.	'High rates of attrition'.	'Minimal use'.	▪ Target males. ▪ Strategies to retain participants are required. ▪ Assess feasibility and cost, as well as weight loss success, compared to traditional int.	*Strengths* ▪ Reports only on web-based int. in adults. *Limitations* ▪ One database searched only, with simplistic search strategy. ▪ No critical appraisal of articles. ▪ No definition of overweight/obesity.
Enwald and Huotari 2010 (34)	*Inclusion criteria* ▪ RCT or pseudo RCT ▪ Published until Aug 2009. ▪ Second-generation computer int. ▪ DB, PA, WLM int. *Included studies* ▪ n=23 (21 RCT, 2 non-randomised) ▪ 10 DB, 7 PA, 2 DB & PA and 4 WLM.	Not reported	▪ Seven studies found significant between group effects for behavioural, psychological or physiological outcomes. ▪ Tailored int. results strongest.	3 to 80%	Not reported	▪ A large number of critical issues should be considered when designing int. studies. ▪ Need to minimise bias in studies.	*Strengths* ▪ Thorough literature review. *Limitations* ▪ No critical appraisal. ▪ No limited to WM interventions. ▪ Adults and children included. ▪ Limited to a specific type of web-based int.

Abbreviations: DB: Dietary Behaviour; Int: Intervention; PA: Physical activity; RCT: Randomised control trial; WL: Weight loss; WM: Weight management; WLM: Weight loss maintenance; Yr: Year.

The diverse results from the five reviews are most likely due to the varying methodologies, as well as methodological weaknesses. The participants studied across the reviews were not homogenous. Two of the reviews included children, as well as adults (28, 34), and not all reviews focused solely on overweight and obese individuals (35). The interventions ranged from all types of eHealth interventions (28) to focusing specifically on one form of web-based intervention (34). The reviews also concentrated on weight loss interventions only (27), weight loss and maintenance interventions (33, 35), or interventions aimed at changing weight, physical activity and/or dietary behaviours (28, 34). Several of the reviews conducted limited literature searches (27, 33, 35), particularly the most recently published review which searched just one database (PubMed) (33). The diverse inclusion criterion are highlighted by the variation in the number of studies included in each review, which ranged from six (27) to 39 (28) studies. The reviews also included studies published in different years, due to the diverse inclusion criteria, as well as the time period which the review was undertaken. It is therefore possible that the results were influenced by potential improvements in web-based interventions over time due to the increasing capabilities of the Internet, as well as improvements in researchers experience and knowledge. Finally, only one of the reviews (28) critically appraised the included studies, to judge their quality.

Therefore, the five reviews do not accurately assess the efficacy of web-based interventions aiming to achieve weight loss or weight loss maintenance. A high quality, up-to-date systematic review of the literature is required. The review should consider the variation in study aims, including the purpose of the intervention (i.e. weight loss and/or weight loss maintenance), as well as the comparisons being made between groups (e.g. intervention vs. control, web-based intervention vs. non web-based intervention, web-based intervention vs. web-based intervention). Consideration of the different types of web-based interventions evaluated across studies (e.g. number and type of features) as well as the use of the web-based intervention and attrition is required. If statistically viable, an overall effect size for web-based weight management interventions needs to be calculated.

To determine the efficacy of web-based weight management interventions well-conducted RCTs are required. Table 2.3 summarises 25 RCTs published from 2001 to 2010 that evaluate the weight loss or maintenance achieved by web-based interventions.

Table 2.3 Chronological summary of weight change results across web-based weight management studies

Study	Intervention	Weight change
Randomised controlled trials		
Tate *et al.* 2001 (36)	WL Internet education (n=45) vs. Internet behavioural therapy (n=46) for 6-months.	Significantly greater WL in internet behavioural compared education-only intervention at 3- (-1 vs. -3.2kg) and 6- (-1.3 vs. -2.9kg) months.
Harvey-Berino *et al.* 2002 (37)	WLM Internet (n=15) vs. control (n=15) vs. face-to-face (n=14) for 22-weeks.	No significant difference in WLM between groups after 22-weeks of WLM.
Harvey-Berino *et al.* 2002 (38)	WLM Internet (n=40) vs. face-to-face frequent (n=41) vs. face-to-face minimal (n=41) for 12-months.	Significantly less WLM in Internet (-5.7kg), compared to face-to-face (minimal -10.4, frequent -10.4kg) after 12-months of WLM.
Tate *et al.* 2003 (39)	WL Internet education (n=46) vs. Internet behavioural therapy (n=46) for 12-months.	Significantly greater WL in behavioural vs. education after 12-months (-4.4 vs. -2.0kg).
Harvey-Berino *et al.* 2004 (40)	WLM Internet (n=77) vs. face-to-face frequent (n=77) vs. face-to-face minimal (n=78) for 12-months.	No significant difference in WLM between Internet (-4.7kg), frequent face-to-face (-3.9kg) or minimal face- to-face (-4.2kg) after 12-months of WLM.
Womble *et al.* 2004 (24)	WL Commercial Internet (n=23) vs. WL manual (n=24) for 12-months.	Significantly less WL Commercial Internet (-0.9,-1.1%) compared to manual (-3.6, -4.0%) after 16- and 52-weeks.
Mobley 2006 (41)	WL Face-to-face (group+ individual) for 3-months (n=43) vs. face-to-face (group) + web-based for 6-months (n=43) vs. face-to-face (individual) for 3-months (n=43) vs. face-to-face (individual)+ web-based for 6-months (n=43).	Significantly greater WL in face-to-face (group + individual -1.0kg) and face-to-face (individual + Internet -0.9kg) then other two groups after 3-months.
Rothert *et al.* 2006 (42)	WL Tailored Internet (n=1475) vs. Information-only Internet (n=1387) for 6-weeks.	Significantly greater WL in tailored Internet vs. information only at 3- (-0.8% vs. -0.4%) and 6- (-0.9% vs. -0.4%) months.
Tate *et al.* 2006 (43)	WL Internet (n=67) vs. Internet with automated feedback (n=61) vs. Internet with human email counselling (n=64) for 6-months.	Significantly greater WL in automated (-4.7kg) and human email counselling (-6.2kg) after 3-months compared to Internet (-3.1kg). Significantly greater WL in human email counselling (-7.0kg) compared to Internet (-3.1kg) after 6-months.
Wing *et al.* 2006 (44)	WLM Internet (n=104) vs. face-to-face (n=105) vs. control (n=105) for 18-months.	Significantly less weigh re-gain in face-to-face compared to control, but no difference in weight re-gain between Internet (2.5kg) and face-to-face (4.7kg) and controls (4.9kg) after 18-months.

Study	Intervention	Weight change
Gold *et al.* 2007 (25)	WL Commercial Internet (n=62) vs. behavioural Internet (n=62) for 12-months.	Significantly greater WL in behavioural Internet (-6.8kg and -5.1kg) and Commercial Internet (-3.3 and -2.6kg) after 6- and 12-months.
McConnon *et al.* 2007 (45)	WL Internet (n=111) vs. usual care (n=110) for 12-months.	No significant difference in WL between Internet (-1.3kg) and usual care (-1.9kg) after 12-months.
Micco *et al.* 2007 (46)	WL Internet vs. Internet (n=62) + in-person support monthly (n=61) for 12-months.	Significant WL by time, but no difference between groups at 6- (-6.8 vs. -5.1kg) or 12-months (-5.1 vs. -3.5kg).
Polzein *et al.* 2007 (47)	WL Individual face-to-face (n=19) vs. individual + Internet vs. individual (n=19) + Internet- restricted (n=19) for 12-weeks.	Significantly different WL between individual (-4.1kg), Internet (-6.2kg) and Internet-restricted (-3.4kg) after 12-weeks.
Carr *et al.* 2008 (48)	WL Internet (n=37) vs. control (n=30) for 16-weeks.	No significant change in weight in Internet or control after 16-weeks.
Cussler *et al.* 2008 (49)	WLM Internet (n=66) vs. self-directed (n=69) for 12-months.	No significant difference in WLM in Internet (0.4kg) to self-directed (0.6kg) after 12-months.
Svetkey *et al.* 2008 (50)	WLM Internet (n=348) vs. individual face-to-face (n=342) vs. control (n=342) for 30-months.	Significantly less weight re-gain in Internet (5.2kg) compared to control (5.5kg), but weight regain was less in face-to-face (4.0kg) after 30-months of WLM.
Webber *et al.* 2008 (51)	WL Internet with MI (minimal) (n=33) vs. Internet with MI (enhanced) (n=33) for 16-weeks.	No significant difference in WL between Internet (-5.2kg) and Internet with MI (-3.7kg) after 16-weeks.
Webber *et al.* 2008 (52)	WL Internet with MI (minimal) (n=16) vs. Internet with MI (enhanced) (n=16) for 8-weeks.	No significant difference in WL between minimal (-2.7kg) and enhanced (-1.5kg) after 8-weeks.
Bennett *et al.* 2009 (53)	WL Internet (n=51) vs. usual care (n=50) for 12-weeks.	Significantly greater WL in Internet (-2.3kg) than usual care (0.3kg) after 12-weeks.
Morgan *et al.* 2009, 2010 (54, 55)	WL Internet (n=34) vs. information (n=31) for 3-months.	No significant difference in WL between Internet (-4.8,-5.3, -5.3kg) and Information (-3.0, -3.5, -3.1kg) after 3- 6- and 12-months.
Van Wier *et al.* 2009 (56)	WL Telephone counselling (n=462) vs. Internet counselling (n=464) vs. control (n=460) for 6-months. Worksite recruitment.	Significantly greater WL in phone (-2.5kg) and Internet (-0.6kg) compared to control after 6-months.

Study	Intervention	Weight change
Harvey-Berino *et al.* 2010 (57)	WL Internet (n=161) vs. face-to-face (n=158) vs. Internet + face-to-face (n=162) for 6-months.	Significantly greater WL in face-to-face (-7.6kg) compared to Internet (-5.5kg) and Internet + face-to-face (-5.7kg) after 6-months. There was no significant difference between Internet and Internet + face-to-face.
Wing *et al.* 2010 (58)	WL Internet (n=90) vs. Internet + online lessons (n=89) for 12-weeks. Recruited from participants signing up for the program in teams.	No significant difference between groups (-1.3 vs. -1.9kg) after 12-weeks.
	WL Internet (n=46) vs. Internet + 1 face-to-face group session + online self-monitoring and feedback (n=82) for 12-weeks. Recruited from participants signing up for the program in teams.	Significantly greater WL in enhanced compared to basic Internet after 12-weeks (-3.1 vs. -1.2. kg)
Observational studies		
Jonasson *et al.* 2008 (59)	WL Internet program (n=37521) for 3, 6 or 12-months.	Mean weight change -5.5% males, and -3.9% females after 3-months, and -7.2% males and -5.3% females after 6-months. Both completers only (n=4209).
Moore *et al.* 2008 (60)	WM Internet (n=2834) for 12-months. Employees of EMC corporation	Sub-group analysis for 203 participants who reported wanting to lose weight at enrolment. Mean weight change -1.4kg after 12-months.
Petersen *et al.* 2008 (61)	Weight gain prevention Virtual Food Pro, web-based intervention for IBM employees (n=7743)	Mean weight change from baseline to 6-months (-2.4kg), and to 12-months (0.3kg).
Ware *et al.* 2008 (62)	WM Worksite. Internet program with accelerometer (n=265) for 12-weeks.	Mean weight change-2.6kg (n=211)
Carter-Edwards *et al.* 2009 (63)	WL Lose to win weight loss challenge for 15-weeks on Herald Sun website (n=705).	Mean weight change -5.9lb (~2.7kg) for completers after 15-weeks (n=154).
McTigue *et al.* 2009 (64)	WL 1 face-to-face consultation + Internet for 1-year (n=50, pilot). Primary care setting.	Mean weight change -4.9kg after 12-months.
Wing *et al.* 2009 (65)	WL Internet program for 16-weeks (n=4717) Team based real-world study.	ITT analysis weight change after 16-weeks: -2.3kg. Completers weight change after 16-weeks-3.2kg. 6-month follow-up (n=1041): Mean weight change -2.4kg

Abbreviations: ITT: Intention-to-treat; MI: Motivational Interviewing; WL: Weight loss; WM: Weight management; WLM: Weight loss maintenance.

The studies compared web-based interventions to no intervention controls or usual care groups (45, 48, 49, 53, 55), two or more types of web-based interventions (25, 36, 39, 42, 43, 51, 52) or web-based interventions to traditional treatment options (e.g. face-to-face consultations) (37, 38, 40, 41, 46, 47, 50, 56, 57). Therefore, the method and purpose of the RCTs conducted to date are diverse, making it difficult to assess their overall efficacy. However, to summarise, four of the studies comparing web-based interventions to a control or usual care group demonstrated significantly greater weight loss or maintenance in the web-based intervention group (47, 50, 53, 56), whilst nine showed no difference in weight outcomes between groups (37, 40, 44-46, 48-50, 55). Three studies found the web-based interventions produced inferior weight outcomes compared to a traditional intervention (24, 38, 57). Studies that compared different types of web-based interventions, generally found achievement of greater weight loss or maintenance from web-based interventions with a greater number of 'enhanced features' or personalised web-based approaches, such as individualised feedback (25, 36, 39, 42, 43, 58).

Seven observational studies evaluating web-based weight management interventions have also been conducted (Table 2.3). The studies (59-63, 65) predominantly observe participants who have enrolled in the web-based interventions, rather than volunteers who have elected to take part in a research study. The purpose of the web-based interventions were to achieve weight loss (59, 63-65) or to maintain participants' current weight (60-62). The weight change ranged from -4.9 (64) to 0.3kg (61), with intervention lengths ranging from 12-weeks (62) to 1-year (59, 60, 64). However, only two of the studies conducted an intention-to-treat analysis (64, 65), while the remaining studies performed a completers analysis only (59-63). The results, therefore, do not represent all participants who enrol in web-based weight management programs. Therefore, there is limited observational research conducted to date that accurately evaluate the extent of weight loss or weight loss maintenance achieved by participants of web-based weight management programs.

Notably, only two RCTs (42, 54) and one observational study (65) have assessed participants' maintenance of lost weight at a future time point following the completion of a web-based intervention. The three studies suggest that maintenance of lost weight is possible. Morgan *et al.* reported a -5.3kg weight change at 9-months post completion of a 3-month web-based intervention, with 58% of participants achieving a weight loss of ≥5% (54). Rothert *et al.* reported significantly greater weight loss maintenance in a tailored Internet group (-2.7 and -3.0%) compared to an information-only internet group (-1.2 and -1.2%) 3- and 6-months post-enrolment in a 6-week intervention. Wing *et al.*

reported an average weight loss of -3.8% in overweight and obese participants 2-months post completion of a 16-week web-based intervention (65). Although these results are promising, they are only from three studies, and therefore unlikely to represent all web-based interventions. Furthermore, they only evaluate weight change within a short timeframe after the completion of the intervention (2- to 6-months). Therefore, evaluating the long-term impact of web-based weight management programs is a key area for future research.

Due to the mixed effectiveness of behavioural interventions in achieving short- and long-term outcomes, we require a better understanding of how to improve weight loss and weight loss maintenance. Table 2.4 outlines a large number of factors associated with greater weight loss and successful weight loss maintenance, including pre-treatment characteristics and characteristics assessed during or post-intervention. Some of the most convincing factors associated with success are behavioural factors. More specifically, individuals eating habits such as: eating breakfast (66-68); consuming less dietary fat (66, 69-74); having consistent meal patterns (66, 69, 72); and less food variety (75, 76) have all been associated with success. Furthermore, individuals who are more physically active (66, 70-72, 74, 77-79) and spend less time watching television or partaking in other sedentary pursuits are also more likely to be successful (66, 80). Weight control practices such as consistent self-monitoring of weight, dietary intake and/or physical activity have also been associated with long-term weight loss success. (66, 69, 71, 81). However, further research is required to continue to identify participant and behavioural factors associated with successful weight loss. This will not only help plan effective web-based interventions, but also provide insight into 'who' is more likely to be successful.

Table 2.4 Participant factors associated with successful weight loss and/or weight loss maintenance

Pre-treatment	Less previous dieting, weight loss attempts and weight cycling (66, 70, 82, 83).
	Self-motivation (70).
	Realistic weight loss goals and expectations (70, 82).
	Losing weight for health related reasons (84).
	Pre-treatment weight/BMI (70, 82).
	Self-efficacy (82) and self-esteem (70).
	Locus of control (70).
	Quality of life related to obesity (70).
	Perceived social support (70).
	No bulimic behaviour (e.g. binge eating) (70).
	Limited barriers to exercise (70).
During/ post-treatment	Greater initial weight loss (66, 85) or reaching a self-determined goal weight (66, 86).
	Consistent self-monitoring (e.g. Weight, eating habits and/or physical activity) (66, 69, 71, 81).
	A physically active lifestyle (66, 70-72, 74, 77-79).
	Minimal perceived barriers to physical activity (69) or healthy eating (69).

	Minimal television viewing or sedentary lifestyle (66, 80).
	Consuming less dietary fat (66, 69-74).
	Less snacking (66).
	Consistent meal patterns/rhythm (66, 69, 72) and less variety in foods consumed (75, 76).
	Eating breakfast (66-68).
	Restricted number of meals from fast food restaurants (79).
	Wanting to lose weight to gain confidence (not for medical reasons or other people) (66).
	No binge, disinhibited, emotional or stress eating (66) .
	Social support (66).
	Coping capacity (e.g. cravings) (66) and ability to cover from weight relapses (87).
	Self-efficacy and autonomy (66, 79).
	Non dichotomous thinking style (66, 86).

2.2.3 Web-based interventions ability to engage participants

Effective behavioural weight management interventions should be able to retain and engage overweight and obese individuals, to ensure that the majority complete and actively engage in treatment. High drop-out rates are common in web-based research, and are often around 40% to 50% (88). The intervention dose received by participants is also variable, due to disparities in how often participants use website features. Typically, participants reduce their use of the website dramatically after the initial weeks (88). Therefore, participants may not drop-out of the intervention, but fail to actively participate (88). For this reason, Eysenbach suggested that exploration of attrition rates include evaluation of drop-out attrition rates (i.e. participants who do not complete the study/program), as well as non-usage attrition rates (i.e. participants who stop using the website) (89). Describing attrition in this manner will provide improved understanding of how participants respond to and use web-based interventions. Eysenbach also highlighted the importance of exploring 'patterns and predictors' of attrition in web-based research (89). By identifying the participants who are more likely to complete and actively participate in web-based interventions, we may be able to identify the group of individuals most suited to the treatment medium, as well as those who may require further support to complete and/or engage. Finally, given the novelty of the treatment medium, we also require further understanding of the level of engagement required by participants to achieve their health or weight loss goals.

Drop-out attrition in web-based weight management interventions

Drop-out attrition rates (i.e. participants who do not complete the study/program) are often high in weight management interventions, with an average of 21% of participants who have enrolled in weight loss studies published from 1996 to 2002 dropping out (90). Three previous reviews of web-based weight management interventions (Table 2.2) reported highly variable attrition rates (28, 34, 35), and acknowledged high drop-out attrition rates in a number of studies (28, 33-35). The RCTs show similar levels of drop-out attrition, with 14 of the 25 RCTs reporting drop-out attrition rates greater than

20% in the web-based intervention arm(s) of the study (24, 25, 36, 38-40, 42, 43, 45, 46, 48, 49, 52, 56). It also appears that the study environment of the RCT may enhance intervention completion, as the drop-out attrition rates in the observational studies are as high as 94% (59) (Table 2.5).

Table 2.5 Chronological summary of drop-out attrition in web-based weight management studies

Study	Drop-out attrition rates by study arm
Randomised controlled trials	
Tate *et al.* 2001 (36)	29% Education, 22% Behavioural.
Harvey-Berino *et al.* 2002 (37)	0% face-to-face, 13% Internet, 7% Control.
Harvey-Berino *et al.* 2002 (38)	25% Internet, 22% Frequent, 32% Minimal.
Tate *et al.* 2003 (39)	23% Education, 16% Behavioural.
Harvey-Berino *et al.* 2004 (40)	32% Internet, 21% Frequent, 19% Minimal.
Womble *et al.* 2004 (24)	35% Commercial Internet, 33% Weight loss manual.
Mobley *et al.* 2006 (41)	26% attrition across groups.
Rother *et al.* 2006 (42)	70% at 3-months and 80% at 6-months.
Tate *et al.* 2006 (43)	12% Internet, 28% Internet with automated feedback, 19% Internet with human counselling.
Wing *et al.* 2006 (44)	7% Control group, 3% Internet group, 12% Face-to-face.
Gold *et al.* 2007 (25)	18% 6- and 25% 12-months Commercial Internet. 19% 6- and 23% 12-months Behavioural Internet.
McConnon *et al.* 2007 (45)	51% Internet, 30% Usual care.
Micco *et al.* 2007 (46)	27% Internet, 28% Internet + support.
Polzein *et al.* 2007 (47)	12% all participants.
Carr *et al.* 2008 (48)	62% Internet, 40% Control.
Cussler *et al.* 2008 (49)	21% Internet group, 15% Self-directed.
Svetkey *et al.* 2008 (50, 91)	6% control, 7% Internet, 6% Face-to-face.
Webber *et al.* 2008 (51)	0% Internet with MI, 1% Internet.
Webber *et al.* 2008 (52)	44% Minimal, 44% Enhanced.
Bennett *et al.* 2009 (53)	16% Internet, 16% Usual care.
Harvey-Berino *et al.* 2010 (57)	1% Internet group, 5% Face-to-face, 6% Internet + Face-to-face.
Morgan *et al.* 2009, 2010 (54, 55)	18%, 18%, 24% Internet at 3-, 6-, 12-months, 13% 16% 36% Information at 3-, 6-, 12-months.
Van Wier *et al.* 2009 (56)	30% Control, 28% Phone, 28% Internet.
Wing *et al.* 2010 (58)	4% Internet, 7% Internet + lessons.
	16% Standard, 10% Enhanced.
	Observational studies
Jonasson *et al.* 2008 (59)	94%, 88%, 93% of 3-, 6- and 12-month members.
Moore *et al.* 2008 (60)	74%.
Petersen *et al* 2008 (61)	79% 6-month 73% 12-month.
Ware *et al.* 2008 (62)	233 started program. 11/233 dropped-out (5%).
McTigue *et al.* 2009 (64)	10%.
Wing 2009 *et al.* (65)	30% did not complete 16-weeks.

Interestingly, drop-out attrition rates are predominantly lower in control or minimal intervention groups compared to web-based interventions (37, 45, 48-50, 55). However, there are no universal differences in web-based interventions attrition rates, when compared to face-to-face interventions. This suggests that it may be participation in the weight management intervention itself, not the treatment medium, influencing drop-out attrition rates. Web-based weight management interventions with more enhanced features, such as tailored information and counselling, may improve drop-out attrition rates (36, 39, 43, 92), but this is not conclusive. Therefore, an important

challenge for web-based weight management interventions is to improve drop-out attrition to ensure most participants complete treatment.

Website use and non-usage attrition in web-based weight management interventions

Norman ***et al's*** review highlighted that many web-based interventions suffer 'low dose and poor usage'. However, it is difficult to ascertain from the studies conducted to date whether participants use of web-based weight management interventions is actually 'low' or 'poor' (Table 2.6). Most studies report use of website features as a mean or median (24, 25, 36-40, 43, 45-48, 51, 53, 55, 58, 59, 62, 64, 91), which does not allow evaluation compared to an expected use, or between web-based interventions. A growing number of studies have reported use of web-based interventions in a more informative way. This includes as a percentage of: the number of times/days participants could have used (37, 38, 44, 46, 57); participants who used website feature(s) (49, 93) and participants who used the website features to the level prescribed (45, 49, 53, 55, 57, 91). Studies that report results as a percentage of the maximum number of times/days participants could have used the program (37, 38, 44, 46, 57) have demonstrated variable results. The proportion of online group or chat sessions attended ranged from 33% (37) to 76% (57), the proportion of self-monitoring diaries completed ranged from 19% (38) to 73% (57), and the proportion of weekly weigh-ins completed peaked at 82% initially and decreased to 55% later in the intervention (44).

It is also difficult to determine from the available literature whether participants reduce their use of web-based weight management interventions after the initial weeks, as seen with other web-based health interventions (88). A number of studies have reported a decrease in log-ins (36, 39, 43, 46, 51, 53), online meeting or chat room attendance (37, 44), self-monitoring (44, 47), weigh-ins (63) or overall website use (25, 42, 45, 60, 62) over time, but this is not universally reported. Furthermore, less than half of the studies (Table 2.6) provide an evaluation of how often participants use the web-based intervention. This highlights the lack of a uniform approach to evaluating website usage data. Interestingly, of the studies that provided an evaluation of how often participants used their program, most concluded that use was high (46, 49, 50, 53, 57, 58, 62, 93). However, most of these studies reported dissimilar results for average use of the website.

Table 2.6 Chronological summary of website use in web-based weight management studies

Study	Website use metrics	Authors evaluation of use	Change in website use overtime	Difference between groups	Website use associated with weight loss
Randomised controlled trials					
Tate *et al.* 2001 (36)	▪ Mean log-ins.	Not evaluated.	Log-ins declined significantly.	▪ Log-ins greater in behavioural group compared to education.	Yes: Log-ins both groups.
Harvey-Berino *et al.* 2002 (37)	▪ Mean peer support contacts. ▪ Proportion of participants attending meetings and submitting weekly self-monitoring diary.	Not evaluated.	Not reported.	▪ Face-to-face group higher meeting attendance than Internet. ▪ No difference in peer support contacts or self-monitoring.	Not reported.
Harvey-Berino 2002 *et al.* (38)	▪ Mean peer support contacts. ▪ Proportion of participants attending meetings and submitting weekly self-monitoring diary.	Not evaluated.	Meeting attendance declined.	▪ More peer support contacts in internet then face-to-face group. ▪ Attendance at group sessions higher in face-to- face compared to Internet. ▪ No difference in self-monitoring between groups.	Not reported.
Tate *et al.* 2003 (39)	▪ Mean monthly log-ins.	Not evaluated.	Log-ins declined.	▪ Log-ins greater in behavioural group compared to education.	Yes: Log-ins both groups.
Harvey-Berino *et al.* 2004 (40)	▪ Mean attendance at online meetings, self-monitoring, and peer-support contacts.	Not evaluated.	Not reported.	▪ Internet group greater self-monitoring, and peer support compared to face-to-face frequent group. ▪ Face-to-face group higher attendance at meetings.	Yes: attendance at treatment meetings, chat sessions, and frequency of self-monitoring.
Womble *et al.* 2004 (24)	▪ Mean food records. ▪ Mean log-ins.	Minimal.	Not reported.	▪ No difference between Internet and manual in food records.	Yes: food records No: Log-ins.

Study	Website use metrics	Authors evaluation of use	Change in website use overtime	Difference between groups	Website use associated with weight loss
Cussler *et al.* 2008 (49)	▪ Mean diet log, weight logged, physical activity logged, 'your week' log, participants contacted, non-participants contacted, articles accessed, articles posted). ▪ Proportion of participants who used feature. ▪ Proportion of participants who used feature once per week.	High.	Not reported.	▪ Not applicable.	Yes: Log-ins.
Gold *et al.* 2007 (25)	▪ Median log-ins, weigh-ins and attendance at facilitated meetings from 0 -to 6-months and 6- to 12-months.	Not evaluated.	Lower total use from 6-12 months, compared to 0- to 6-months for both groups.	▪ More log-ins, weigh-ins and meeting attendance in behavioural internet.	Yes: Behavioural Internet group: log-ins, weigh-ins, online meeting, and most page features Commercial group: log-ins, weigh-ins, and viewing bulletin board 0- to 6- months.
Harvey-Berino *et al.* 2010 (57)	▪ Proportion of group sessions attended, and self-monitoring journals submitted.	High.	Not reported.	▪ No difference between Internet, face-to-face or Internet + face-to-face groups.	Not reported.
Rothert *et al.* 2006 (42, 94)	▪ Proportion of participants with initial and ongoing engagement.	Not evaluated.	Ongoing engagement less than initial.	▪ Proportion different by tailored and information-only Internet groups but statistical significance not reported.	Not reported.
Tate *et al.* 2006 (43)	▪ Median log-ins.	Not evaluated.	Log-ins declined.	▪ Internet and Internet with human counselling group logged-in more than Internet with automated feedback group. ▪ Human counselling group made more diary entries than automated feedback group.	Yes: Log-ins and diary entries.
Wing *et al.* 2006 (44)	▪ Proportion of chat sessions attendance.	Not evaluated.	Significant decrease in chat sessions and	▪ Higher session attendance in face-to-face group than Internet.	Not reported.

Study	Website use metrics	Authors evaluation of use	Change in website use overtime	Difference between groups	Website use associated with weight loss
			weigh-ins.	▪ No difference in weigh-ins.	
McConnon *et al.* 2007 (45)	▪ Mean log-ins. ▪ Proportion of participants who used website.	Minimal.	Proportion of participants who reported using the website declined from 0-6 to 6-12 months.	▪ Not applicable.	No: Log-ins.
Micco *et al.* 2007 (46)	▪ Mean log-ins. ▪ Proportion of group meetings attended. ▪ Proportion completed homework assignments, self-monitoring journals and met calorie goals.	High.	Log-ins declined in second half of study.	▪ No difference in log-ins, or proportion completed homework assignments, self-monitoring journals and met calorie goals Internet and Internet + face-to-face groups.	Not reported.
Polzein *et al.* 2007 (47)	▪ Mean meals logged 12-weeks and from week 1 to 4, 5 to 8 and 9 to 12.	Not evaluated.	Meals logged Decreased.	▪ No difference between groups in meals logged in Internet and Internet + face-to-face groups.	Yes: Meals logged Internet + face-to-face.
Svetkey *et al.* 2008 (50)	▪ Proportion of participants using consistently, some and minimal. ▪ Median and tertiles of use: log-ins, minutes spent on website, weight entries, exercise entries, bulletin board messages read and posted.	High.	Not reported.	▪ Not applicable.	Yes: consistent users, median, and tertiles of use.
Webber *et al.* 2008 (51)	▪ Mean log-ins, self-monitoring diaries, message board posts.	Low (chat attendance).	Log-ins declined.	▪ No difference in log-ins or diary use between minimal and enhanced internet groups. ▪ More message board posts in enhanced group.	Yes: log-ins, self-monitoring, attendance at chat sessions and message board posts.
Morgan *et al.* 2009 (55)	▪ Mean diet and exercise diary entries, and weekly weigh-ins. ▪ Proportion of participants who complied.	Poor.	Not reported.	▪ Not applicable.	Yes: diet entries, exercise entries and number of weekly check-ins.
Wing *et al.* 2010 (58)	▪ Mean weigh-ins, total number of strategies, and use of specific features.	High.	Not reported.	▪ No difference between Internet and Internet with online lessons group for any features.	Not reported.

Study	Website use metrics	Authors evaluation of use	Change in website use overtime	Difference between groups	Website use associated with weight loss
		High.	Not reported.	▪ No difference between Internet and Enhanced Internet group.	Yes: calorie reporting and lessons viewed in enhanced group.
Observational studies					
Verheijden *et al.* 2007 (95)	▪ Proportion of participants who visited the website 1, 2, 3 times.	Not evaluated.	Not reported.	▪ Not applicable.	Not reported.
Jonasson *et al.* 2008 (59)	▪ Mean log-ins, diary entries, and weigh-ins.	Low compliance.	Not reported.	▪ Not applicable.	Yes: Log-ins, diary entries and weigh-ins.
Moore *et al.* 2008 (60)	▪ Number of users per 4-week period. ▪ Average number of uses per 4-week period.	Not evaluated.	Number of users declined.	▪ Not applicable.	No: Log-ins.
Petersen *et al.* 2008 (61)	▪ Numbers of users logged in 0-2 days, 3-11 days and >12 days.	Not evaluated.	Not reported.	▪ Not applicable.	Yes: Log-ins.
Ware *et al.* 2008 (62)	▪ Non-usage attrition. ▪ Mean log-ins (total, weekdays, and weekends). ▪ Mean minutes spent on website.	Higher than other programs.	Time spent on website declined.	▪ Not applicable.	Yes: Total website use.
Carter-Edwards *et al.* 2009 (63)	▪ Proportion of participants who entered weight at week 1 and 15.	Not evaluated.	Decline in weigh-ins from week 1 to 15 (22% at week 15).	▪ Not applicable.	Not applicable.
McTuigue *et al.* 2009 (64)	▪ Mean log-ins, week's weighed-ins, self-monitored diet and physical activity. Proportion completing lessons.	Not evaluated.	Not reported.	▪ Not applicable.	Not reported.
Binks *et al.* 2010 (93)	▪ Proportion of participants who used each website component.	Some features high.	Not reported.	▪ Not applicable.	Not reported.

Therefore, given the diversity in reporting website use for web-based weight management interventions, its evaluation is complicated. From the available evidence (Table 2.6), it appears that use of web-based weight management interventions is diverse, declines over time and may depend on the type of web-based features provided. The research reviewed highlights that researchers must start to report the level of website usage prescribed to participants as part of the intervention. They also must move beyond reporting 'average use' when describing website use, and report it in a way that allows comparison across different web-based interventions, and over time. Therefore, the development of standardised website usage metrics is vital. Such definitions will help web-based researchers understand how individuals utilise different web-based weight management interventions (88), and what level of usage is needed to optimise weight loss outcomes. However, due to the heterogeneous nature of web-based interventions (e.g. intervention length, website features, and expected use) this is a complex task. Eyensbach's recommendation to explore non-usage attrition is an important first step in providing a website usage metric that allows greater comparability between studies. To date, only two web-based weight management interventions (62, 96) have reported non-usage attrition rates. Therefore, more studies reporting non-usage attrition rates are needed.

Website use and treatment outcomes

Website use is consistently associated with improvements in weight-related outcomes. The majority of RCTs and observational studies that have investigated the association between intervention exposure and outcomes have demonstrated greater use of the web-based intervention is associated with greater weight loss or weight loss maintenance (Table 2.6). This includes the number of log-ins (25, 36, 39, 43, 45, 49, 53, 59, 61), self-monitoring of weight, diet and/or exercise (24, 25, 40, 43, 47, 51, 55, 58, 59), attendance at online meetings/chat sessions (25, 40, 51), number of forum posts (25, 51), viewing online lessons (58) and overall website use (62, 91). Furthermore, the type of web-based features provided may influence user engagement. The first web-based weight management RCTs comparing 'enhanced' web-based interventions (including features such as behavioural therapy, human counselling and additional support or motivation) to education-based interventions demonstrated greater website use with the 'enhanced' programs (25, 36, 39, 43). This included a greater number of log-ins (25, 36, 39, 43), self-monitoring occasions (25, 43), attendance at online meetings (25), and number of forum posts made (25). However, more recently conducted RCTs have failed to demonstrate a difference in website use between the 'enhanced' and basic web-based interventions (42, 51, 58)

(Table 2.6). Therefore, the ability of web-based weight management interventions to engage participants is a potentially crucial component of effectiveness and may be related to the type of website features provided, and is an important area of future development.

Participant characteristics associated with drop-out and non-usage attrition

The ability of web-based interventions to promote website use and retain participants is vital. Through identification of the type of individuals who are more or less likely to complete web-based treatment and/or use the website, we can identify those who may need further support to complete and/or participate in web-based treatment, as well as 'who' is best suited to the treatment medium. Such knowledge will assist in the development of strategies to improve attrition and website use, and potentially improve overall treatment outcomes.

Previous research has investigated many different demographic, health-related and behavioural variables as potential predictors of drop-out attrition from weight loss interventions, including a limited number of web-based interventions. Socio-demographic characteristics potentially associated with increased risk of drop-out include the lowest (97) or highest (98) education level, being employed (97, 99), and being younger (98, 100, 101). Health and behavioural factors have also been associated with drop-out attrition, including a greater number of previous weight loss attempts (82, 102), poor emotional status (98, 102) and higher weight loss expectations (82, 100). However, no consistent predictors of drop-out attrition from weight management interventions have been determined. Only a small number of studies have investigated pre-treatment predictors of non-usage attrition. Pre-treatment characteristics shown to be associated with increased risk of non-usage include: gender (being male or female) (94, 96), younger age (94-96), poor motivation (94), being non-obese (95), lower levels of physical activity (95) and poor eating behaviours (95). However, like predictors of drop-out attrition, no consistent predictors of non-usage attrition have been identified. Therefore, further research assessing predictors of drop-out and non-usage attrition in web-based weight management interventions is required.

2.2.4 Reach of web-based behaviour change interventions

As previously outlined, effective behavioural weight management interventions must have the ability to reach and provide treatment to a large number of individuals. Web-based interventions have great potential to reach a large number of people. Today, there are nearly two billion Internet users worldwide, including 17 million Australians

(80%) (21). In Australia, 72% of households have access to the Internet (103), and access doubled in the 5-year period from 2001 to 2006 (104). Of those who have access to the Internet, most now have access to fast download speeds (105). Internet access is also becoming increasingly portable, with 3.5 million Australians using mobile wireless devices (105), and this does not include individuals with access to Internet via their mobile/cell phone. However, a 'digital divide' still exists with lower Internet access rates in rural and remote areas, in households with lower weekly incomes and among the older population, aged greater than 65 years (104). Although, the 'digital divide' among older age groups has lessened in recent years (106).

The Internet is also an appealing way for individuals to access information about their health, with many using the Internet to obtain information about health, nutrition, physical activity and weight loss. It has been estimated that 61% of adults in the United States use the Internet for health-related information (107). Furthermore, 24% of adults have looked online for information about losing or controlling their weight (107). Women, younger adults (aged 18 to 29 years) and individuals from higher income households, who are highly educated, are more likely to look online for general health information, including information related to weight loss (107).

Web-based interventions also have the potential to access normally hard-to-reach groups. Using the Internet to deliver behaviour change interventions may allow participants who are unable to access traditional treatment modes (e.g. face-to-face consultations) to participate. The anonymous nature of the web allows those who are normally too afraid or vulnerable to gain support to participate (26-28, 108). Busy individuals with demanding work or life commitments can access web-based interventions at a time that is most suitable to them (26, 28, 109, 110) and individuals in areas where access to health care services is restricted (e.g. in rural and remote areas) may be able to access the Internet instead.

We currently do not know the socio-demographic or behavioural characteristics of individuals who are likely to participate in web-based weight management interventions. This is because the majority of research is undertaken in clinical research settings with convenience samples of volunteers. As outlined in Table 2.7, the majority of RCTs have recruited white, well-educated, middle- aged women. Interestingly, the small number of observational studies conducted, have described populations with a similar demographic profile. This suggests that the Internet may not reach a more diverse group of individuals, as hypothesised. Two studies (60, 62) were able to recruit more males than other studies, but participants were recruited through

worksites. Therefore, the higher proportion of male participants is most likely due to a higher number of males in these settings.

Table 2.7 Chronological summary of web-based weight management studies reporting program reach

Study	Reach
Randomised controlled trials	
Tate *et al.* 2001 (36)	89% Female, Age: 18 to 60 years, Educated.
Harvey-Berino *et al.* 2002 (37)	80% Female, Age: Mean 46 years, Educated.
Harvey-Berino *et al.* 2002 (38)	85% Female, Age: Mean ~47 years, Educated, 98% White.
Tate *et al.* 2003 (39)	89% Female, Age: Mean 49 years, 89% White, Educated.
Harvey-Berino *et al.* 2004 (40)	82% Female, Age: Mean 46 years, Educated.
Womble *et al.* 2004 (24)	100% Female, Age: Mean 44 years.
Mobley 2006 (60)	37% Female, Age: Mean 33 years, 49% White, Educated, Military personnel.
Rothert *et al.* 2006 (42)	83% Female, Age: Mean 46 years, 57% White.
Tate *et al.* 2006 (43)	84% Female, Age: Mean ~49 years, ~6% Minority ethnicity, Educated.
Wing *et al.* 2006 (44)	~81% Female, Age: Mean ~51 years.
Gold *et al.* 2007 (25)	82% Female, Age: Mean 47 years, 98% White, Highly educated.
McConnon *et al.* 2007 (45)	77% Female, Age: Mean 46 years, 95% White.
Polzein *et al* .2007 (47)	98% Female, Age Mean ~41 years.
Micco *et al.* 2007 (46)	83% Female, Age: Mean 47 years, Predominantly white, Educated.
Carr *et al.* 2008 (48)	81% Female, Age: Mean 41-49 years (Completers only).
Custer *et al.* 2008 (49)	100% Female, Age: Mean 48 years.
Svetkey *et al.* 2008 (50)	63% Female, Age: Mean 55.6 years, 38% African American, Educated.
Webber *et al.* 2008 (51)	100% Female, Age: Mean 50 years, 86% Caucasian, Variable education levels.
Webber *et al.* 2008 (52)	100% Female, Age: Mean 41 years, 75% white, Highly educated.
Bennett *et al.* 2009 (53)	47% Female, Age: Mean 54 years, 50% White, Educated.
Morgan *et al.* 2009,2010 (54, 55)	0% Female, Age: Mean 36 years.
Van Wier *et al.* 2009 (56)	33% Female, Age: Mean 43 years, Educated.
Harvey-Berino *et al.* 2010 (57)	93% Female, Age: Mean 47 years, 28% African-American, Highly educated.
Wing *et al.* 2010 (58)	83% Female, Age: Mean 47 years, Highly educated, 88% White.
	90% Female, Age: Mean 47 years, Highly educated, 88% White.
Observational studies	
Verheijden *et al.* 2007 (95)	2/3 Female, Age: Mean 36 years, Highly educated
Moore *et al.* 2008 (60)	45% Female, Age: Mean 41 years, Highly educated, Predominantly white.
Petersen *et al.* 2008 (61)	60% Female, 5.7% of Employees enrolled.
Ware *et al.* 2008 (62)	51% Female, Age: Mean 41 years, 92% white, 12% of Employees enrolled.
Jonasson *et al.* 2009 (59)	86% Female, Moderate education.
McTigue *et al.* 2009 (64)	76% Female, Age: Mean 52 years, 86% white, Highly educated
Wing *et al.* 2009 (65)	82% Female, Age: Mean ~42 years.
Binks *et al.* 2010 (93)	82% Female, Age: Mean 42 years.

Therefore, despite their potential to reach a large number of people, including hard-to-reach groups, participants who partake in web-based health interventions cannot currently be characterised. This is because few web-based interventions have comprehensively described the characteristics of individuals who participate, and whether the program reached its intended target group. Therefore, further research is required to evaluate the reach of web-based weight management interventions, by describing the socio-demographic, as well as behavioural characteristics of individuals

who enrol. It has been recommended that reach be assessed as per the RE-AIM framework (88).The reach (R) dimension of the RE-AIM framework involves evaluating the number of participants from the intended target group who participated in an intervention, and also whether the participants were representative of the target group in terms of their demographic characteristics (111), as well as other intervention specific characteristics (e.g. weight loss interventions may also look at the number of overweight vs. obese individuals).

2.2.5 The state of the evidence: Web-based weight management interventions

To summarise, web-based interventions offer a logical and feasible strategy to achieve weight loss or weight loss maintenance. Web-based interventions have the potential to reach a large number of people, provide tailored support and achieve modest effects on weight-related outcomes. However, further research should focus on improving attrition rates (drop-out and non-usage), as well as developing a better understanding of the types of individuals who participate in web-based interventions, and of this group, who actively participates and completes the intervention.

Furthermore, evaluations of web-based interventions are commonly conducted as RCTs, whereby convenience samples of participants who wish to lose weight, consent to being studied, and often receive reimbursement, are recruited rather than actual participants of the program (88). Therefore, misrepresentation of program reach, weight-related outcomes, attrition and website use may have occurred from the studies conducted to date. This is due to the characteristics of research volunteers, as well as the rigor of the study design (e.g. motivated participants, additional assessment sessions, subject retention strategies, greater accountability and contact with study staff). Therefore, studies following usual participants of web-based weight management interventions are required, to confirm the reach, attrition rates and impact on weight-related outcomes in the ‘real-world’.

Remarkably, most scientifically evaluated web-based weight management interventions are not available to the public. Commercial web-based weight loss program are likely to be the most accessible web-based interventions for consumers (23). However, only one commercial web-based weight loss program has been scientifically evaluated (eDiets, www.ediets.com), in two RCTs (24, 25). Therefore, little is known about the overall effectiveness of commercial programs in achieving weight loss or maintenance, as well as their ability to recruit, retain, and engage their target group. The next section of the literature review evaluates the effectiveness of

commercial weight management programs (Section 2.3.1), as well as their ability to engage (Section 2.3.2) and reach (Section 2.3.3) their intended target group.

2.3 Commercial weight management programs

2.3.1 Effectiveness of commercial weight management programs

The most recent systematic review of major commercial weight loss programs was conducted by Tsai and Wadden and included research published up until October 2003 (112). The review evaluated commercial programs available in the Unites States and included face-to-face, web-based and meal-replacement programs. They noted that Weight Watchers, a face-to-face group based program, was the only major commercial weight loss program with published evidence from RCTs to demonstrate that the program achieves an average weight loss of at least 5% after 12-weeks, 1- or 2-years of treatment. They concluded that there was inadequate evidence to recommend the use of commercial weight loss programs, and that controlled trials need to be undertaken to determine the efficacy of the treatment medium (112).

Since Tsai and Wadden's review in 2003, results from only five pertinent RCTs have been published, including one web-based program (Table 2.8). Two RCTs have tested the efficacy of the Jenny Craig program and suggest an average weight loss of approximately -7% to -8% can be achieved after the 12-month intervention (113, 114). Two RCTs have also assessed the weight loss achieved by commercial weight loss programs (Weight Watchers and Rosemary Conely) compared to other popular weight loss diets (e.g. the Zone, Atkins). Dansinger *et al.* found that participants achieved an average of -3kg weight loss after 12-months participating in Weight Watchers (115), while Truby *et al.* found that participants achieved a mean weight loss of -7.3% after 6-months participating in Weight Watchers, and -7% after 6-months of participating in Rosemary Conley (116). Both studies found that the commercial weight loss programs were not superior to the other weight loss diets in terms of weight loss achieved. Gold *et al.* compared a commercial web-based weight loss program (eDiets) to a non-commercial web-based program (VTrim), and found that despite significant weight loss being achieved in the eDiets group (-3.6% after 6-months and -2.8% after 12-months), it was significantly less than the VTrim group (-7.3% after 6-months and -5.5% after 12-months) (25).

Table 2.8 Chronological summary of commercial weight loss program RCTs published after October 2003

Study	Participants	Intervention, length and assessments	Attrition rates	Weight loss results
Dansinger *et al*. 2005 (115)	n=160. Age: Adults (Mean 49 years). 51% women.	Atkins (n=40) vs. Zone. (n=40) vs. Weight Watchers (n=40) vs. Ornish (n=40) for 12-months. Assessments at 0, 2, 6 and 12-months.	Atkins: 48%. Zone: 35%. Weight Watchers: 35%. Ornish: 50% at 12-months.	ITT analysis. All groups showed significant weight loss from baseline to 2, 6 and 12 months. No significant differences between groups demonstrated. Atkins: -3.6kg, -3.2kg and -2.1kg. Zone: -3.8kg, -3.4kg and -3.2kg. Weight Watchers: -3.5kg , -3.5kg, -3.0kg. Ornish; -3.6kg, -3.6kg -3.3kg at 2-, 6- and 12-months.
Gold *et al.* 2007 (25)	n=124. Age>18 years. 82% female.	Ediets.com: commercial web-based program (n=62) vs. Vtrim: non-commercial behavioural web-based program (n=62) for 12-months. Assessments at 0, 6- and 12-months.	Ediets: 19% at 6-months, 23% at 12-months VTrim: 18% at 6 months, 35% at 12-months.	ITT analysis. VTrim group lost significantly more weight than eDiets at 6-months (-7.3 vs.- 3.6%) and maintained a greater loss at 12-months (-5.5 vs. -2.8%).
Truby *et al.* 2009 (116)	n=293. Age: 18 to 65 years. 73% women.	Atkins (n=57) vs. Weight Watchers (n=58) vs. Slim Fast (n=59) vs. Rosemary Conley (n=58) vs. Control (n=61) for 6-months. Assessments at 0, 2- and 6-months.	Atkins: 19% and 30% . Weight Watchers: 10% and 19% Slim Fast: 17% and 29% . Rosemary Conley: 21% and 29% Control: 33% and 34% at 2- and 6-months.	ITT analysis. No significant difference between weight loss across intervention groups at 2 and 6-months, all significantly higher than control groups. Atkins: -5.5% and -6.2%. Weight Watchers: -5.1% and -7.3%. Slim-Fast: -3.8% and -4.9%. Rosemary Conley: -4.5% and -7.0%. Control: 0.4% and -0.6% at 2 and 6-months.
Rock *et al.* 2010 (114)	n= 442. Age: 18 to 69 years. 100% women.	Jenny Craig: face-to-face consultations (n=169) vs. Jenny Craig with telephone consultations (n=164) vs. Usual care control: s (n=111) for 2-years. Assessments at 0, 6, 12 and 24-months.	Jenny Craig Face: 5%. Jenny Craig Phone: 1%. Control: 3% at 2-years.	Significantly greater weight loss in Jenny Craig groups compared to control at 12- (-10.9% vs.-9.2% vs. -2.6%) 24- (-7.9% vs. -6.8% vs.- 2.1%) months.

Abbreviation: ITT:Intention-to-treat

The RCTs had several strengths, including their design and use of intention-to-treat analysis. However, two of the studies recruited only women (113, 114), and two included predominantly women (25, 116). Therefore the results from these studies, particularly the two Jenny Craig RCTs (113, 114), may not be valid for males. Furthermore, participants in all the studies were provided with free access to the program, which included group or one-on-one consultations (113, 114, 116), online or telephone support (25, 113, 114), written materials (115), and food (113, 114). Therefore, it is unlikely that the results from these trials are generalizable to all overweight and obese individuals in the community, and may present a 'best-case scenario' (117). As the results of the RCTs are unlikely to be generalizable to usual enrolees, it has been suggested that studies following actual commercial weight loss program participants be conducted. Such studies will provide an improved understanding of the nature of consumers engagement with commercial programs and the degree of weight loss that can be expected in the 'real-world' as opposed to the clinical research environment (112, 118).

A small number of studies (Table 2.9 and 2.10) have evaluated the weight loss achieved by usual participants of commercial weight loss programs. This includes studies following cohorts of participants for the length of their membership (Table 2.9), as well as studies re-contacting participants to assess their long-term weight loss maintenance (Table 2.10). All of the studies report promising results in terms of the average weight loss achieved during program participation, as well as long-term weight loss maintenance. However, there are number of methodological limitations that bias the study results. Three cohort studies (119-121) reported weight loss results for completers only, meaning that the results are only applicable to participants who complete the commercial weight loss programs and not all participants who commence treatment. As some of the studies report high attrition rates (up to 93%), this is a major limitation. The one study that conducted an intention-to-treat analysis, presented results as weight loss from enrolment to last program week, and used a 'modified' intention-to-treat approach whereby participants were only included in the analysis if they had attended at least two sessions of the commercial program (119). Therefore, the results do not provide insight into the true weight loss achieved after specific treatment durations (e.g. 3-, 6- or 12- months), nor are they truly representative of all participants who seek treatment using a commercial weight loss program.

Table 2.9 Chronological summary of commercial weight loss program cohort studies

Study	Participants	Intervention description, length and assessments	Attrition rates	Weight loss results
Bye *et al.* 2005 (121)	n=67. Age: 29-71 years. 0% women	Slimming World for at least 8-weeks. Assessments at 0-, 8-, 12- and 24-weeks.	Not reported.	Members for at least 12-weeks prior to data collection (n = 53), mean weight loss at week 12 was - 9.2kg. Members for at least 24-weeks prior to data collection (n = 16) lost on average at week 24, -11.4%
Finley *et al.* 2007 (120)	n=60164 Age: 18-79 years. % women not reported.	Jenny Craig. Platinum program for up to 1-year. Assessments conducted weekly.	4-weeks: 27%. 13-weeks: 58%. 26-weeks: 78%. 52-weeks: 93%. Defined as drop-out if 6 or more consecutive weeks without recorded weight.	Presented as % weight loss from baseline to final week of membership Weeks 1-4: -1.1% Weeks 5-13: -4.3% Weeks 14-26: -7.3% Weeks 27-39: -9.4% Weeks 40-52: -12.3%
Martin *et al.* 2010 (119)	n=145095. Age: Adults (Mean 43 years). Majority female (92%).	Three variants of Jenny Craig Platinum for up to 52-weeks (n=60164), Rewards program for up to 52-weeks (n=81505) Gold program: for up to 26-weeks (n=3426) Assessments conducted weekly for first 26-weeks, monthly thereafter.	Only reported in figure. Average length of membership: Platinum: 16.3 weeks. Rewards: 19.5 weeks. Gold: 9.2 weeks. Significant difference Platinum and rewards programs.	ITT analysis: weight change from baseline to last week of attendance. Platinum: -5.5% Rewards: -6.4% Weight change from baseline to last week of attendance (up to 26-weeks). Gold -4.1% Rewards -10.1% Completers analysis: Percentage weight loss at week Week 13: Platinum -7.5%. Rewards: -8.2%. Week 26: Platinum: -10.5%, Rewards -11.4%. Week 52: Platinum:-12.3%, Rewards -13.0%. All significant differences between programs.

Abbreviation: ITT: Intention-to-treat

Five studies involved contacting participants of commercial weight loss programs up to 11-years post-treatment to assess their long-term maintenance of lost weight (Table 2.10). Three of the studies evaluated the same commercial program (Weight Watchers) (122-124). All studies relied on self-reported weight measures, but three conducted sub-studies to evaluate the magnitude of misreporting among participants, and adjusted for this, therefore improving the validity of the results (122, 124, 125). Selection of study participants was biased in all five studies. One study included only female participants who had completed 1-month of treatment (126), while the other studies included only participants who had reached their goal weight when participating in the program (122-125). Therefore, the results are not representative of all consumers who enrol in the commercial weight loss programs, and may misrepresent the degree of long-term weight loss maintenance.

Table 2.10 Chronological summary of commercial weight loss program long-term follow-up studies

Study	Participants	Intervention description, length and assessments.	Weight loss results
Wolfe 1992 (125)	n=267. Age: Mean 45 years. 'Majority' female Random sample who had completed program.	Jenny Craig: including weekly one-on-one consultations and group session, and food provided. Assessment: 1-year post completion.	82% remained within 10% of their post-treatment weights at the time of the follow-up.
Christakis and Miller-Kovach 1996 (123)	n=1200. Age: Adult (most 35-65 years). 94% women. Lifetime members.	Weight Watchers: weekly sessions and hypocaloric diet. Intervention length varied. Assessment: 1-, 2-, 3-, 4-, 5- and >6 years since reached goal weight. N=200 for each time point.	67% maintained their weight goal within 5 pounds (2.3kg). 37% of participants who were lifetime members >5 years maintained their weight goal within 5 pounds (2.3kg).
Gosselin and Cote 2001 (126)	n=291. Age: Average 43.0 years. 100% women. Random sample.	Mincavi: recipe book, calorie restriction, large group consultations, and telephone/e-mail support from dietitian. Member for at least 1-month. Assessments: at 2-years after participants joined program, and up to 11-years after.	Presented as % weight loss maintained after: 2-years: 7.0%. 3-years 4.5%. 4-years: 3.4%. 5-6 years: 4.7%. 7-8 years: 3.5%. 9-11 years 3.4%. Overall: 4.5%.
Lowe *et al.* 2001 (124)	n=1002. Age: Adults. 96% women. Lifetime members.	Weight Watchers: weekly sessions and hypocaloric diet. Intervention length varied. Assessments: 1-, 2-, 3-, 4-, 5-years since reached goal weight. N for each time unclear.	Presented as weight regain (kg) after 1-year: 1.7kg. 2-years: 3.7kg. 3-years: 4.2kg. 4-years 5.6kg. 5-years: 5.4kg. Overall: 3.9kg.
Lowe *et al*. 2008 (122)	n=699. Age: Adults (71% >45 years). 95% women. Lifetime members.	Weight Watchers: weekly sessions and hypocaloric diet. Intervention length varied. Assessments 1- (n=272), 2- (n=279) or 5- (n=148) years since reached goal weight.	Presented as weight regain (kg) after 1-year: 2.2kg. 2 years: 3.5kg. 5 years: 4.7kg.

2.3.2 Commercial weight management ability to engage participants

Tsai and Wadden's systematic review of commercial weight management program reports drop-out attrition rates ranging from 18% to 67% (112). This suggests that the number of participants, who drop-out of commercial programs, is highly variable, and can be very high. RCTs conducted since the systematic review (Table 2.8) also report variable drop-out attrition rates ranging from 1% among Jenny Craig participants after 2-years (114), to 35% of Weight Watchers participants after 12-months (115). These drop-out attrition rates are likely to be influenced by a number of intervention (e.g. provision of meals) and study (e.g. number of follow-ups) related factors. As previously outlined, the results from the RCTs are unlikely to be generalizable to usual participants of the commercial weight loss programs. A more accurate evaluation of

drop-out attrition rates among usual participants of commercial weight loss programs comes from the cohort studies conducted to date (Table 2.9). The studies suggest that drop-out attrition rates are potentially much higher among usual enrolees, than in RCTs. For example, the Jenny Craig program reported high attrition rates, with nearly 30% of participants dropping out within the first 4-weeks of treatment, and over 90% by 1-year (120). However, as there are only a limited number of RCTs and observational studies assessing commercial programs, further research is required to evaluate drop-out attrition rates.

2.3.3 Reach of commercial weight management interventions

A large number of consumers, in Australia and throughout the developed world, utilise commercial weight management programs when trying to lose weight. In the United States, it has been estimated that 13% of females and 5% of males who are trying to lose weight, use commercial programs (127). However, these estimates date back to 1991, when the prevalence of overweight and obesity was significantly less, so current use may be higher. The results from cohort studies (Table 2.9) also highlight the large number of individuals who take part in commercial programs. For example, Martin *et al.* report on just over 145000 individuals who enrolled in either the Jenny Craig Platinum or Rewards program in 1-year in the United States alone (119). It also appears from the available evidence that middle-aged women, of higher socio-economic status are more likely to participate in commercial weight loss programs (Table 2.8 to 2.10). However, no studies have described the demographic or behavioural characteristics of commercial weight loss program members in detail, nor described the potential reach or how representative enrolees are of the target group. Therefore, further research is required to ascertain the reach of commercial weight management interventions.

2.3.4 The state of the evidence: Commercial weight management programs

Therefore, the literature review demonstrates that the evidence-base regarding the efficacy and effectiveness of commercial weight loss programs is currently limited and of poor quality. This is also true for commercial web-based interventions. Available research also suggests that drop-out rates are high among subscribers to commercial weight loss program. Therefore, further research is urgently required to ascertain the efficacy of commercial weight loss programs, as well as to evaluate consumers' engagement with such programs and the degree of weight loss that can be expected in the 'real-world'.

2.4 Assessing dietary intake via the Internet

2.4.1 Importance of assessing dietary intake

Assessment of food intake has two vital roles in behavioural weight management interventions. Firstly, food intake is commonly assessed as a secondary outcome in controlled and observational studies, as an indicator of adherence to the prescribed dietary intervention. Secondly, self-monitoring of food intake is an essential component of behavioural interventions (Section 1.1.2), as well as web-based weight management interventions (Section 2.2.1).

2.4.2 The use of food diaries to assess dietary intake

Self-monitoring of food intake is generally undertaken using a food diary or record. A food diary requires participants to record the type and amount of food or beverage consumed (128, 129). Portion sizes may be measured using scales or household measurements or estimated using food models or pictures, or without assistance (129). Depending on the setting, and reason for recording dietary intake, training on how to complete the diary may be provided, to ensure respondents record an adequate description of foods consumed. Training is most commonly provided if the diary is being completed to assess dietary intake as an outcome in a research study, and researchers may review the diary after completion, and consult with the respondent to improve accuracy and completion rates.

Food diaries are commonly completed in a paper-based format, for both self-monitoring and research purposes (130). Paper-based food diaries offer several benefits to the respondent, and to researchers in comparison to other dietary intake measurement tools (Table 2.11). The main strength of the method is that food diaries are prospective, so they do not rely on participants' memory, thereby reducing recall bias. They are also flexible, allowing respondents to complete at the time of food or drink consumption, in an open-ended format (128, 130). However, food diaries also have a number of limitations (Table 2.11). They are labour intensive for the respondent to complete, and therefore require time and motivation on their part, as well as moderate literacy (128). Due to this labour intensity, respondents may not complete the diary at the time of food consumption, which can introduce recall bias (131). When using a food diary for self-monitoring purposes, it is difficult for individuals to easily, and accurately evaluate their dietary intake, without the assistance of a dietitian or the use of a calorie counter or other food composition list. Finally, as the method is prospective, participants may alter

their eating habits, so they are able to report socially desirable foods, or to make the reporting process less burdensome (128).

2.4.3 The use of web-based food diaries to assess dietary intake

Web-based weight management interventions provide an innovative approach to self-monitoring and data collection, whereby a food diary can be completed on the website. Web-based food diaries are similar to traditional diaries, whereby respondents report the type and amount of food consumed. However, food and drinks are commonly selected from a list of similar items, generated from a web-based search of a food and beverage database. Because the diary is linked to a food composition database, it can provide real-time feedback on the nutrient composition of individual food items, as well as assessment of respondents combined intake (e.g. daily, weekly). Respondents can use the analysis to assist with behaviour modification and researchers can use to evaluate compliance with prescribed diets, as well as nutritional adequacy.

Table 2.11 Strengths and limitations of food diaries and how they may differ for web-based food diaries

All food diaries	Web-based food diary
Strengths	
Reduces reliance on participant's memory, as recorded at time of consumption.	May not be recorded at time of consumption, as respondent may not have access to the Internet at that time.
Can be completed away from home, therefore flexible for participants.	Can be completed away from home, but only if have access to the Internet.
Measure of current diet.	Strength for all food diaries, as well as web-based food diaries.
Open-ended so no limitation on what food and beverages participants can record.	Dependant on food items available within food composition database linked to web-based diary.
Inexpensive to provide to participants.	Expensive to develop. Also requires participants to have Internet access.
Limitations	
Labour intensive for participants to complete.	Potentially reduces the labour intensity, due to ability to select food items from list and duplicate commonly consumed food items.
Motivation required.	Real-time feedback and reduction in labour intensity may improve motivation.
Requires moderate literacy skills.	Requires literacy skills, as well as computer/Internet skills.
Recall bias can be introduced if not completed at time of food consumption.	Consistent limitation for all food diaries and web-based diaries, especially if individual does not have access to Internet away from home.
Difficult to easily, and accurately evaluate dietary intake when completed, as requires access to an energy and nutrient database.	Can provide real-time feedback to individuals, as well as researchers.
Can alter the type/amounts of food consumed.	Consistent limitation for all food diaries and web-based diaries. Real-time feedback may enhance this effect.

Web-based food diaries offer several advantages over traditional paper-based diaries (Table 2.11). They may reduce participant burden by simplify the recording process. The provision of real-time feedback may improve participant motivation, and therefore

completion of the diary. However, web-based food diaries also have some limitations. Because they require access to the Internet, participants may not complete the diary until sometime after food consumption, therefore introducing a recall bias. If the diary is linked to a food composition database, it is dependent on the quality of the database, as well as the number of items it contains, and how regularly it is updated. Given the ever-changing food supply, it is unlikely that a food composition database will include all food items available at one time (132). Finally, the provision of real-time feedback on the nutrient composition of reported foods may further alter the type of foods that respondents consume and/or record. Therefore, a web-based diary may not provide an accurate description of respondents' usual intake.

The overall impact of these strengths and limitations on the accuracy of dietary intake reported using a web-based food diary has not been evaluated. We know that, individuals commonly misreport their intake when completing a paper-based food diary. Studies that have compared total EI derived from food diaries, to an objective measure such as the DLW technique, have indicated that misreporting of EI is prevalent and on average under-estimated by 4% to 37% (133). Therefore, research is required to evaluate the accuracy of web-based food diaries, as part of evaluating their worth as a dietary assessment and self-monitoring tool.

2.5 Summary of literature review

To summarise, the chapter provides a comprehensive review of web-based weight management interventions. The overall effectiveness of web-based weight management interventions, although promising, is currently unknown. A high quality systematic review of the literature is therefore required. The review also highlights, despite there being several hypothesised benefits of web-based weight management interventions, further research is required to evaluate their ability to appeal to, retain and engage overweight and obese adults. Most readily accessible web-based weight management programs are currently provided by the commercial sector; however there is limited evidence available to support their use. Therefore, further research is urgently required. More specifically, we require greater understanding of participants' engagement with commercial programs and the degree of weight loss that can be expected from this treatment mode in the 'real-world'. Finally, the literature review identifies the potential for data to be collected as part of a web-based weight management intervention, specifically focusing on dietary intake data. The review identifies, that no research has been conducted to evaluate the accuracy of dietary intake data collected using a web-based food diary.

Chapter Three: Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: A systematic review with meta-analysis

This chapter was published in 2010.

Neve M, Morgan PJ, Jones PR, Collins CE. 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* 2010; 11(4):306-321

The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 5). Permission to reproduce the text and figures from the manuscript has been granted by the publishers.

3.1 Introduction

Lifestyle interventions to treat overweight and obesity have been effective in achieving moderate weight loss in the short term. However, currently there is no universally effective approach to weight management that ensures long-term maintenance of lost weight (19, 90). Furthermore, cost-effective interventions that are generalizable in real world settings are still required (19). Web-based weight management programs offer a logical and feasible strategy to treat large numbers of overweight individuals, although to date this medium has been relatively under-utilised and under-evaluated.

Several reviews have explored the effectiveness of web-based and more broadly e-Health interventions, on improving outcomes in the area of weight management, physical activity and dietary intake with equivocal results (27, 28, 35, 109, 110). Preliminary studies suggest that web-based interventions may be an effective means to facilitate weight loss (35). Further exploration of web-based interventions on weight management is warranted as it is a research area that is growing rapidly and two of the preceding reviews were limited to studies up until 2006 (27, 35). Researchers have highlighted the need to examine which specific elements of web-based interventions enhance the impact on outcome measures, as well as those that increase participation and reduce attrition rates (109, 110). This knowledge will assist in the development of effective interventions that are able to engage and retain large numbers of individuals, potentially enhancing population weight-related health and well-being, which would be of significant public health value.

Therefore, the primary objective is to assess the effectiveness of web-based interventions for weight loss and maintenance of weight loss in overweight and obese adults through use of a systematic review and meta-analysis. Individual interventions were defined as effective if a mean percentage weight loss ≥5% was achieved or maintained, as this is the benchmark for clinically significant weight loss and improvement in weight-related morbidity (6, 14). Pooled effectiveness of web-based interventions for weight loss and weight loss maintenance will be determined through meta-analysis. The second objective is to identify which specific components of web-based interventions are associated with greater weight loss and maintenance, as well as low attrition rates.

3.2 Methods

This study was conducted using a protocol that was peer reviewed by the JBI. The JBI is an international research organisation for evidence-based health care. The protocol

can be accessed at: http://0-www.joannabriggs.edu.au.library.newcastle.edu.au/protocols/Protocol220.pdf**.**

3.2.1 Criteria for study inclusion

Studies were included in the review if they were RCTs with at least one web-based intervention study arm whose primary aim was achieving weight loss or weight loss maintenance. Interventions were considered web-based if participants received information and directly interfaced with the web but they were not required to input information into the website for inclusion. Studies with the aim of achieving positive dietary and physical activity behaviour change with adiposity outcome measures were included. In addition, participants had to be aged 18 years or over with a BMI≥25. The effects of the interventions were assessed through absolute and/or percentage change in body weight.

3.2.2 Literature search

The search strategy identified both published and unpublished studies in the English language from 1995 onwards. This date was selected, as prior to this web-based interventions and public access to the Internet were uncommon. To identify appropriate keywords, an initial limited search of MEDLINE and CINAHL was undertaken and the title, abstract and index terms used to describe the articles were undertaken. All identified keywords and index terms were used in the second search of The Cochrane Library, MEDLINE/PREMEDLINE, EMBASE, CINAHL, Web of Science, Scopus PsycINFO, Australian Digital Theses Program, and Dissertation & Abstracts. The reference lists of all retrieved articles were searched for additional studies.

3.2.3 Study selection

All studies identified in the database search were assessed for relevance from the title, abstract and keywords by two independent reviewers. Studies that met all or it was uncertain if they met the inclusion criteria, were retrieved. All retrieved studies were assessed for relevance by two independent reviews. In case of disagreement, a third independent reviewer made the final decision.

3.2.4 Critical appraisal

Included studies were assessed by two independent reviewers for methodological validity using a standardised critical appraisal instrument from the JBI Meta-Analysis of Statistics Assessment and Review Instrument. Any disagreements between the reviewers were resolved by a third independent reviewer.

3.2.5 Data extraction

Data in relation to methodology, intervention effect and compliance with and intensity of the web-based interventions were extracted by the first reviewer using a standardised form developed by the researchers. The form was checked by the second reviewer and a consensus reached where disagreement existed. Authors were contacted if further details were required.

3.2.6 Data synthesis

For each outcome measure, results were described in a narrative summary. Results were pooled in meta-analysis if they were available as either change scores or final values, presented as means with standard deviations (SD), the number of participants was recorded and interventions were similar enough for comparison. Heterogeneity was assessed using chi-squared with significant heterogeneity assigned at a p <0.10. If significant heterogeneity existed, the random effects model was used for statistical analysis; if homogenous, the fixed effect model was used. For continuous outcomes, the data from individual studies were combined across studies using either weighted mean difference (WMD) or standardised mean difference (SMD). If the same measurement scales were used WMD was calculated. If varying measurement scales were used that were still considered comparable (e.g. weight and percentage weight loss), SMD was used. All meta-analyses were conducted using RevMan Analyses 1.0.5, 2003 (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark)

3.3 Results

3.3.1 Description of included studies

Of the 181 articles identified, 20 were included, three were classified as ongoing studies that met all inclusion criteria except having reported intervention effect measures, and 151 were excluded (Figure 3.1). Of the 20 articles, 18 different studies were described and study characteristics are outlined in Table 3.1.

The total number of participants across all studies was 5700, of which at least 77% were female (3.7% unclear). Eleven studies had two intervention arms (24, 25, 36, 39, 42, 45, 46, 48, 49, 134), six had three arms (37, 38, 40, 43, 47, 50, 135), and one had four intervention arms (41). Thirteen studies had the primary aim of achieving weight loss (24, 25, 36, 39, 42, 45, 47, 48, 50, 134), and five focused on maintenance of weight loss. The length of the intervention period ranged from 6-weeks to 2-years.

Eight interventions were 12-months in duration (24, 25, 38-40, 45, 46, 49). Eight interventions ranged from 6-weeks to 6-months (36, 37, 42, 43, 47, 48, 134), one was 2-years (50), and one varied depending on the study arm (41). Only one study followed up participants beyond the intervention period and this involved follow-up at 3- and 6-months after a 6-week intervention (42). Retention rates varied from 48 to 100% at the post-intervention time point. Eight studies retained greater than 80% of participants (37, 39, 43, 47, 49, 50, 134), five retained 60 to 80% (24, 25, 36, 38, 40, 46) and two 40 to 60% (45, 48), one did not provide retention rates for the end of the intervention (42), and one intervention length varied (41). All but one study was conducted in the United States and this was conducted in the UK (45).

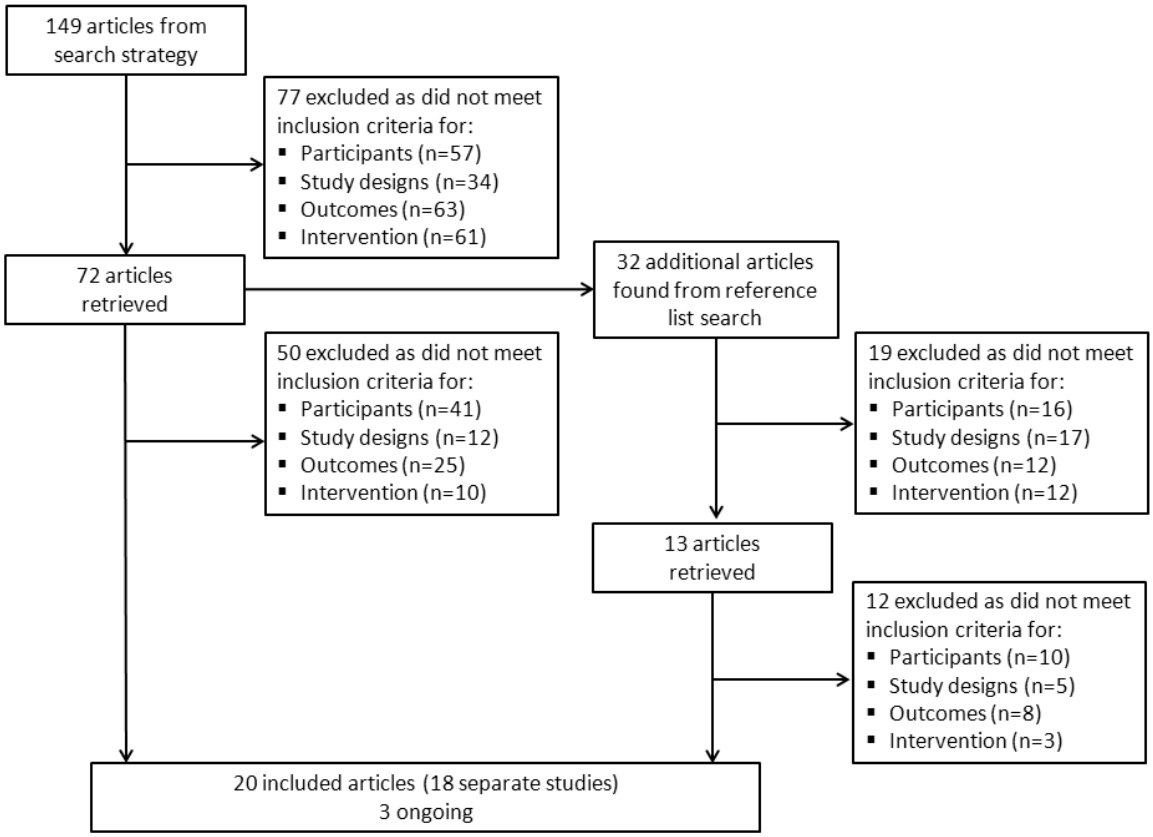


Figure 3.1 Identifying studies for inclusion

Table 3.1 Study characteristics of web-based interventions for weight loss and weight loss maintenance

Study	*N*	Male: Female	Retention	Setting	Length of intervention	Follow-up	Intervention
Carr *et al.* 2008 (48)	67	Unclear	48% (32/67)	USA	14-weeks	None	a) WL web (PA only) (n=37) b) Control (waiting list) (n=30)
Cussler *et al.* 2008 (49)	135	0:135	82% (111/135)	USA	12-months	None	a) WLM web (n=66) b) Usual care control (n=69)
Gold *et al.* 2007 (25)	124	23:101	71% (88/124)	USA	12-months	None	a) WL commercial web-based (n=62) b) WL behavioural web-based (n=62)
Harvey-Berino *et al.* 2004 (40)	232	38:194	76% (176/232)	USA	12-months	None	a) WLM web-based (n=77) b) WLM frequent face-to-face (Gp) (n=77) c) WLM minimal face-to-face (Gp) (n=78)
Harvey-Berino *et al.* 2002a (38)	122	18:104	76% (93/122)	USA	12-months	None	a) WLM web-based (n= 40) b) WLM frequent face-to-face (Gp) (n=41) c) WLM minimal face-to-face (Gp) (n=41)
Harvey-Berino *et al.* 2002b (37)	44	Unclear	96% (42/44)	USA	22-weeks	None	a) WLM web-based (n=15) b) WLM face-to-face (Gp) (n=14) c) Control: No intervention (n=15)
McConnon *et al.* 2007 (45)	221	51:170	59% (131/221)	UK	12-months	None	a) WL web-based (n=111) b) Usual care control (n=110)
Micco *et al.* 2007 (46)	123	21:102	79% (26/123)	USA	12-months	None	a) WL web-based (n=62) b) WL web-based and face-to-face (Gp) (n=61)
Mobley 2006 (41)	172	109:63	72% (123/172) at 3- months	USA	3- or 6- months	None	a) WL face-to-face (Gp) and face-to-face (Ind) follow-up (3-months) (n=43) b) WL face-to-face (Gp) and web-based follow-up (6-months) (n =43) c) WL face-to-face (Ind) and face-to-face (Ind) follow-up (3- months) (n=43) d) WL face-to-face (Ind) and web-based follow-up (6-months) (n=43)
Polzein *et al.* 2007 (47, 136)	58	1:57	86% (50/58)	USA	12-weeks	None	a) WL face-to-face (Ind) (n=19) b) WL face-to-face (Ind) and web-based (intermittent) (n=19) c) WL face-to-face (Ind) and web-based (continuous) (n=19)

Rothert *et al.* 2006 (42)	2862	487:2375	30% (867/2862) at 3-months 20% (585/2862) at 6-months	USA	6-weeks	3- and 6-months	a) WL web-based individually tailored (n=1475) b) WL web-based information only (n=1387)
Svetkey *et al.* 2008 (50)	1032	382:650	93% (964/1032)	USA	24-months	None	a) WLM self-directed (n=342) b) WLM web-based (primarily) and phone calls (n=347) c) WLM phone (primarily) and face-to-face (individual) (n=342)
Tate *et al.* 2006 (43)	192	30:162	81% (155/192)	USA	6-months	None	a) WL meal replacements with website (n=67) a) WL meal replacements with website and automated email feedback (n=61) c) WL meal replacements with website and human emailing counselling (n=64)
Tate *et al.* 2003 (39)	92	9:83	84% (77/92)	USA	12-months	None	a) WL web-based education only (n=46) b) WL web-based education and behavioural therapy (n=46)
Tate *et al.* 2001 (36)	91	10:81	78% (71/91)	USA	6-months	None	a) WL web-based education only (n=45) b) WL web-based education and behavioural therapy (n=46)
Webber 2007 (134) a) Pilot study b) Final study	20	0:20	90% (18/20)	USA	8-weeks	None	a) WL web-based with motivational interviewing (n=10) b) WL web-based with motivational interviewing and values discussion (n=10)
	66	0:66	100% (66/66)	USA	16-weeks	None	a) WL web-based with minimal motivational interviewing (n=33) b) WL web-based with enhanced motivational interviewing (n=33)
Womble *et al.* 2004 (24)	47	0:47	66% (31/47)	USA	12-months	None	a) WL web-based (n=23) b) WL manual (n=24)

Abbreviations: Ind, Individual; PA, physical activity; WL, weight loss; WLM, weight loss maintenance.

Interventions with the primary aim of achieving weight loss explored four distinct research areas. First, web-based programs compared with a control or minimal intervention group (n=3) (24, 45, 48). Second, generic web-based programs compared with enhanced web-based programs (n=5) (25, 36, 39, 42, 43). This included comparison of a commercial web-based program with a web-based program with behavioural therapy (n=1) (25); individually tailored web-based program with an education only web-based program (n=1) (42); web-based program with a web-program with automated email feedback or human email counselling (n=1) (43) and an education only web-based program with a web-based program with education and behavioural therapy (n=2) (36, 39).The third group of interventions compared web-based programs with different types of face-to-face sessions (individual or group), with or without web-based interventions (n=3) (41, 46, 47). Finally, two studies explored the use of different intensities of motivational interviewing within a web-based program (134).

Interventions with the primary aim of achieving weight loss maintenance following a standard weight loss program were also diverse, with three different research questions addressed among them. Web-based programs were compared with a control or minimal intervention group (n=2) (37, 49); face-to-face group sessions (n=3) (37, 38, 40); telephone follow-up to a self-directed control group and telephone follow-up with face-to-face individual sessions (n=1) (50).

3.3.2 Quality of included studies

No studies were able to fulfil all requirements for a high-quality study. Three studies were able to meet eight of the 10 requirements (39, 43, 45). Fourteen of the studies, despite being described as a RCTs, did not specify the method of randomisation to groups (24, 25, 36-38, 40-42, 46-49, 134). It was, therefore, also unclear whether those allocating participants to treatment groups were blinded in these studies. The majority conducted an intention-to-treat analysis (n=14) (24, 25, 36, 38-43, 45-50); had comparable groups at entry (n=14) (24, 25, 36, 38-43, 45, 47, 49, 134); measured outcomes in a reliable manner (n=16) (24, 25, 36-41, 43, 45-50, 134) and used appropriate statistical analyses (n=17) (24, 25, 36, 38-43, 45-50, 134). All studies measured outcomes consistently for both groups, and treated groups identically, other than the stated intervention.

3.3.3 Effectiveness of web-based interventions aiming to achieve weight loss

The results for total and percentage weight change are described in Table 3.2. Twelve studies reported total weight change (24, 25, 36, 39, 41, 43, 45-48, 134), while six studies reported percentage weight change (24, 25, 39, 42, 43, 47). Of the six studies who reported percentage weight change, three were successful in achieving 5% or greater weight change in one or more study arms (25, 43, 47).

Three studies compared web-based weight loss interventions with minimal interventions or control groups (24, 45, 48) with differing results. Carr *et al.* and McConnon *et al.* showed no significant difference in weight change between a web-based intervention and a control group (45, 48). Alternatively, Womble *et al.* compared a commercially available web-based program with a weight loss manual, and found significantly greater weight loss among the weight loss manual group at mid- (16-weeks: −0.7 [2.7] vs. −3.0 [3.1], $p = 0.01$) and post-intervention (52-weeks: −0.8 [3.6] vs. −3.3 [4.1], $p = 0.04$) (24). It was unclear whether two of the studies were effective in achieving a percentage weight change of 5% or more (45, 48), while neither the commercially available web-based program nor the weight loss manual group were defined as effective at mid- (16-weeks: −0.9 [3.2] vs. 3.6 [4.0]) or post-intervention (52-weeks: −1.1 [4.0] vs. −4.0 [5.1]), based on percentage weight change (24). When pooled in a meta-analysis (Figure 3.2), the interventions were shown to be significantly heterogeneous ($\chi^2 = 12.84$, d.f. = 2 [$p = 0.002$], $I^2 = 84.4\%$) and there was no significant difference in weight change between the web-based intervention and control groups at post-intervention (SMD 0.73 [−0.06, 1.51] Z = 1.81 [$p = 0.07$]).

Table 3.2 Weight-related outcomes for web-based interventions for weight loss and weight loss maintenance

Study	Measurement	Results	Significant difference between groups	Effective[a]
Weight loss interventions				
Carr *et al.* 2008 (48)	Mean weight at 0 and 16-weeks	a) n=14, 0: 91.1 (5.0) 16-weeks: 90.3 (5.2) b)n=18, 0 : 83.3 (6.6) 16-weeks: 82.9 (6.6)	No	Unclear
Gold *et al.* 2007 (25)	Mean weight change at 6- and 12-months	a) n=62, 6-months: −3.3 (5.8), 12-months: −2.6 (5.3) b) n=62, 6-months: −6.8 (7.8), 12-months: −5.1 (7.1)	Yes: greater loss in group B at 6- and 12-months ($p = 0.005$, 0.034)	Yes: group B at 6- & 12-months

Study	Measurement	Results	Significant difference between groups	Effective[a]
	Mean percentage weight change at 6- and 12-months	a) n=62, 6-months: −3.6 (6.1) 12-months: −2.8 (5.5) b) n=62, 6-months: −7.3 (7.8), 12-months: −5.5 (7.6)		
McConnon *et al.* 2007 (45)	Mean weight change at 6- and 12-months	a) n=111, 6-months: −1.19 (5.1) 12-months: −1.3 (5.6) b)n=110, 6-months: −1 (3.7) 12-months: −1.9 (5.9)	No	Unclear
Micco *et al*. 2007 (46)	Mean weight change at 6- and 12-months	a) n=62, 6-months: −6.8 (7.8) 12-months: −5.1 (7.1) b) n=61, 6-months: −5.1 (4.8), 12-months: −3.5 (5.1)	No	Unclear
Mobley 2007[b] (41)	Mean weight change at 3-months	a) n=43, −1.04 (0.46) b) n=43, 0.02 (0.46) c) n=43, −0.24 (0.46) d) n=43, −0.90 (0.46)	Yes: greater loss in group A and group D compared with group B and C at 3-months (p<0.05)	Unclear
Polzein *et al*. 2007 (47, 136)	Mean weight change at 12-weeks	a) n=19: −4.1 (2.8) b) n=19: −3.4 (3.4) c) n=19: −6.2 (4.0)	Yes: greater loss in group C compared with group B at 12-weeks (p=0.03)	Yes: group C at 12-weeks
	Mean percentage weight change at 12-weeks	a) n=19: −4.6 (3.2) b) n=19: −3.8 (3.8) c) n=19: −7.1 (4.6)	Yes: greater loss in group C compared with group B at 12-weeks (p=0.03)	
Rothert *et al.* 2006 (42)	Mean percentage weight change at 3- and 6-months	a) n=1475 3-months: −0.8% (0.1), 6-months:−0.9% (0.1) b) n=1387 3-months: −0.4% (0.1), 6-months: −0.4% (0.1)	Yes: greater loss in group A than group B at 3- and 6-months (p< 0.0005 and p< 0.0001 respectively)	No
Tate *et al*. 2006 (43)	Mean weight change at 3- and 6-months	a) n=67, 3-months: −3.1 (4.0), 6-months: −3.1 (6.0) b) n=61, 3-months: −4.7 (4.3), 6-months: −4.6 (6.1) c) n=64, 3-months: −6.2 (4.2), 6-months: −7.0 (5.7)	Yes: greater loss in group B (p=0.005) and C (p=0.001) compared with group A at 3-months. Greater loss in group C compared with group A at 6-months (p<0.001)	Yes: groups B & C
	Mean percentage weight change at 3- and 6-months	a) n=67, 3-months: −3.3 (3.7), 6-months: −2.8 (5.9) b) n=61, 3-months: −5.8 (4.4), 6-months: −5.3 (6.5) c) n=64, 3-months: −6.8 (3.9), 6-months: −8.1 (6.3)	Unclear	
Tate *et al.* 2003 (39)	Mean weight change at 12-months	a) n=46, −2.0 (5.7) b) n=46, −4.4 (6.2)	Yes: greater loss in group B at 12-months (p=0.04)	No
	Mean percentage weight change at 12-months	a) n=46, −2.2% b) n=46, −4.8%	Yes: greater loss in group B at 12-months (p=0.03)	

Study	Measurement	Results	Significant difference between groups	Effective[a]
Tate *et al.* 2001 (36)	Mean weight change at 3- and 6-months	a) n=45, 3-months: −1.0 (2.4), 6-months: −1.3 (3.0) b) n=46, 3-months: −3.2 (2.9), 6-months: −2.9 (4.4)	Yes: greater loss in group B at 3- (p< 0.001)and 6- months (p=0.04)	Unclear
Webber 2007a (134)	Mean weight change at 8-weeks	a) n=9, −2.7 (2.9) b) n=9, −1.5 (2.2)	No	Unclear
Webber 2007b (134)	Mean weight change at 16-weeks	a) n=33, −5.22 (4.72) b) n=33, −3.71 (4.46)	No	Unclear
Womble *et al.* 2004 (24)	Mean weight change at 16- and 52-weeks	a) n=23, 16-weeks: −0.7 (2.7), 52-weeks: 0.8 (3.6) b) n=23, 16- weeks: −3.0 (3.1), 52-weeks: −3.3 (4.1)	Yes: Greater loss in group B at week 16 (p=0.01) and week 52 (p=0.04)	No
	Mean percentage weight change at 16- and 52-weeks	a) n=23,16-weeks: −0.9% (3.2), 52-weeks: −1.1% (4.0) b) n=23, 16-weeks: −3.6% (4.0), 52-weeks 4.0% (5.1)	Unclear	
Weight loss maintenance interventions				
Cussler *et al*. 2008 (49)	Mean weight change at 12-months	a) n=66, 0.4 (5.0) b) n=69, 0.6 (4.0)	No	Unclear
Harvey-Berino *et al*. 2004 (40)	Mean weight change at 12-months (calculated from −6 months)	a) n=52, −4.7 (6.9) b) n=61, −3.9 (5.9) c) n=63, −4.2 (7.9)	No	Yes
	Mean percentage weight change at 12-months (calculated from −6 months)	a) n=52, −8.2% b) n=61, −5.6% c) n=63, −6.0%	No	
Harvey-Berino *et al.* 2002a (38)	Mean weight change at 12-months (calculated from −6 months)	a) n=32, −5.7 (5.9) b) n=30, −10.4 (6.3) c) n=28, −10.4 (9.3)	Yes: greater loss in groups B & C compared with group A at 12-months (p<0.05)	Unclear
Harvey-Berino *et al.* 2002b (37)	Mean weight change at 22-weeks (calculated from −15 weeks)	a) n=? −15.5 (23.4) b) n=? −19.8 (17.2) c) n=? −17.3 (15.3)	No	Unclear
Svetkey *et al.* 2007 (50)	Mean weight change at 24-months (calculated from −5 months and 0)	a) n=340, −5 to 24-months: −2.9 (0.4) 0 to 24-months: 5.5 (0.3) b) n=346, −5 to 24-months: −3.3 (0.4) 0 to 24-months: 5.2 (0.3) c) n = 340, −5 to 24-months: −4.2 (0.4) 0 to 24-months: 4.0 (0.3)	Yes: greater loss in group C compared with group A (p=0.001) and group B compared with group C (p=0.008) at 24-months	Unclear

[a] If ≥5% weight change achieved; [b]Preliminary results at 6 months only included in thesis;? sample size unclear.

Figure 3.2 A meta-analysis of three RCTs comparing web-based weight loss interventions with control or minimal interventions.

Five studies (25, 36, 39, 42, 43) compared education only web-based interventions with enhanced web-based programs. Gold *et al.* reported significantly greater total and percentage weight loss at mid- (6-months: −6.8 kg [7.8], −7.3% [7.8] vs. −3.3 kg [5.8], −3.6% [6.1], p=0.005) and post-intervention (12-months: −5.1 kg [7.1], −5.5% [7.6] vs. 2.6 kg [7.8], −2.8% [5.5], p= 0.034) from a web-based program with behavioural therapy compared with a commercial web-based program. Therefore, the web-based program with behavioural therapy was deemed effective. The behavioural therapy program included the addition of individual email feedback on self-monitoring of weight, eating and activity, as well as homework activities. Notably, the commercial program included prescriptive meal and exercise plans for participants, while the behavioural program did not (25).

Rothert *et al.* reported significantly greater percentage weight loss at 3 (−0.8% [0.1] vs. −0.4% [0.1], p<0.0005) and 6-months post-intervention (−0.9% [0.1] vs. −0.4% [0.1], p <0.0001) among participants in a 6-week individually tailored web-based program compared with an information only web-site; however, the intervention is not considered effective due to the percentage weight loss achieved being less than 5% at both time-points. The individually tailored program included individualised educational material and a weight management plan generated automatically from baseline assessments, as well as a buddy system and the ability to email other participants (42).

Tate *et al.* (2006) demonstrated significantly greater weight loss at post-intervention among participants of a web-based program with human email counselling compared with a web-based program alone (−7.0 [5.7] vs. −3.1 [6.0], p < 0.001). There was no significant difference in weight loss achieved by a web-based program with automated counselling when compared with the web-based program alone or the web-based program with human email counselling (43). Furthermore, both the web-based programs with human email counselling and automated counselling achieved a percentage weight change greater than 5% at mid- and post-intervention. The main difference between the two-enhanced interventions compared with the web-based program alone was the provision of message boards, a diary to log eating and activity, as well as the feedback on diary entries. Those in the human email counselling group received feedback written individually by a weight loss counsellor based on diary entries, while those in the automated group received automated tailored feedback based on diary entries (43).

Tate *et al.* (2003) and Tate *et al.* (2001) both compared a web-based program with education to web-based programs with education and behavioural therapy. Both studies demonstrated significantly greater weight loss and a reduction in waist

circumference at post-intervention in the web-based programs with education and behavioural therapy (36, 39). Tate *et al.* (2003) did not report percentage weight change, while Tate *et al.* (2001) reported percentage weight loss less than 5% in both the web-based program with education and the web-based program with education and behavioural therapy. The additional behavioural therapy features across both studies were the provision of email feedback from a counsellor based on a participant's self-monitoring of weight, activity and eating habits, as well as a behavioural weight loss lesson. In Tate *et al.* (2001) the behavioural therapy group also received access to a chat room and email contact with other members, while in 2003 these two features were available to both groups (36, 39).

Three studies, corresponding to four study arm comparisons were combined in a meta-analysis (Figure 3.3), comparing weight loss at post-intervention in education only web-based interventions vs. those with enhanced features. Studies were grouped by the type of enhanced intervention (behavioural therapy or counselling). Overall, the studies were shown to be homogenous (χ^2 = 3.79, d.f. = 3 [P = 0.28], I^2 = 20.9%). There was a significant difference in the change in weight between the two groups post-intervention, with a greater decrease in weight in the web-based programs with enhanced features (WMD 2.24 [1.27, 3.21] Z = 4.54 [p<0.00001]).

In summary, there are a limited number of studies to assess the effectiveness of web-based interventions in achieving weight loss. Meta-analyses suggest that web-based interventions achieve similar weight loss to control or minimal intervention groups, and web-based interventions with enhanced features achieve greater weight loss than those with education alone.

3.3.4 Effectiveness of web-based interventions aiming to achieve weight loss maintenance

The results for total and percentage weight change are described in Table 3.2. All weight loss maintenance studies (n=5) reported total weight change. Only one study reported percentage weight change, and it was successful in achieving greater than 5% weight change in two intervention arms (40).

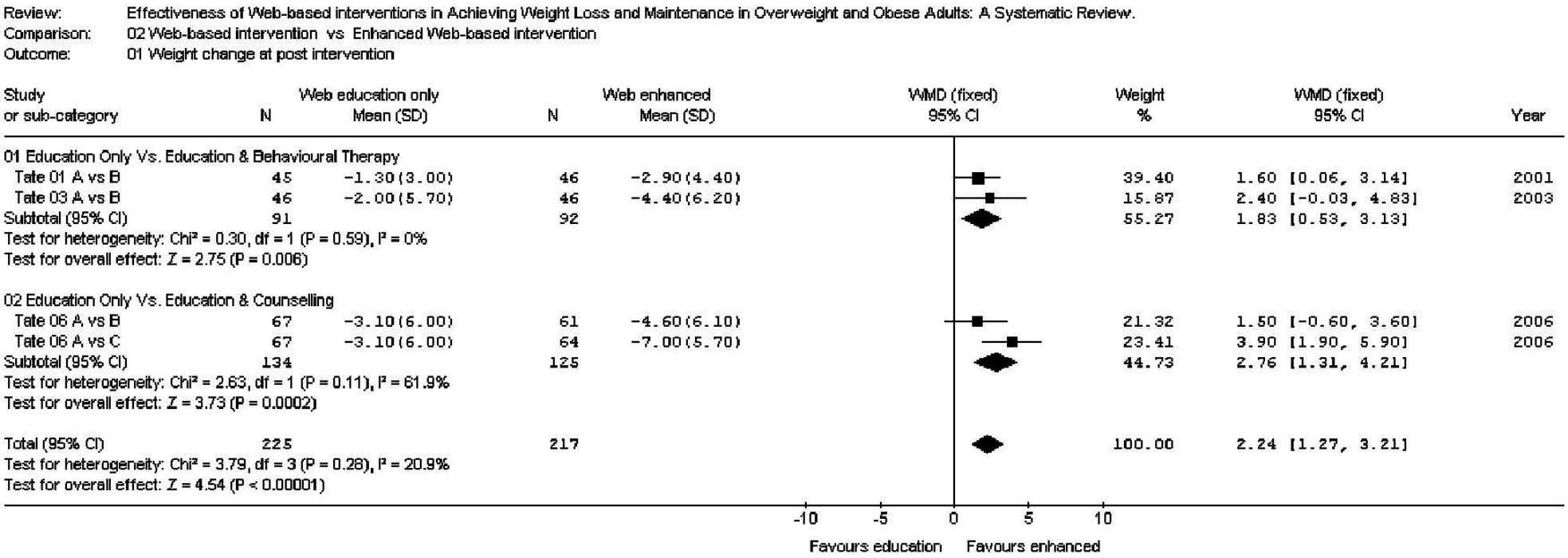


Figure 3.3 A meta-analysis of three RCTs comparing web-based weight loss interventions with education only with enhanced web-based programs.

Three studies (37, 49, 50), with the aim of achieving weight maintenance following a weight loss intervention, compared web-based interventions with minimal interventions or control groups. Two of the three studies were pooled in a meta-analysis comparing weight change after a weight loss maintenance intervention (Figure 3.4). The studies were shown to be significantly homogenous (χ^2 = 0.02, d.f. = 1 [P = 0.90], I^2 = 0%). There was a significant difference in the change in weight between the two groups post-intervention, with less weight re-gained in the web-based program (WMD −0.30 [−0.34,−0.26] Z = 13.10 [p<0.00001]). The third study showed no significant difference between a web-based intervention and control group in terms of weight change at post-intervention (37). None of the studies reported percentage weight change.

Three weight loss maintenance studies compared web-based with group face-to-face interventions (37, 38, 40). Two of the studies had three arms, with a web-based intervention compared with two intensities of face-to-face interventions (38, 40). One study demonstrated significantly better maintenance of weight loss in the two face-to-face groups compared with the web-based intervention, with no significant differences between the two intensities of face-to-face intervention (38). The other study found no significant difference between the three groups, i.e. similar weight loss maintenance in the face-to-face interventions compared with a web-based program (40). Additionally, they did not demonstrate a percentage weight change of greater than 5% in any of the groups. The difference in intensities of the face-to-face groups ranged from bi-weekly group meetings for 12-months compared with monthly groups meetings for 6-months, and no contact for the remaining 6-months of the intervention (38, 40). The two studies were combined in a meta-analysis grouped by intensity of face-to-face intervention (frequent and minimal) (Figure 3.5). Overall, the studies were found to be significantly heterogeneous, (χ^2 = 12.22, d.f. = 3 [p = 0.007], I^2 = 77.5%). There was no significant difference in the maintenance of weight loss between the groups at post-intervention when comparing face-to-face interventions with web-based interventions (WMD 1.80 [−1.18, 4.79] Z = 1.18 [p = 0.24]). There was also no significant difference in the change in weight between the groups for either frequent or minimal intensity face-to-face interventions alone. The third study found no significant difference between a web-based intervention and a face-to-face group intervention in terms of weight change at post-intervention (37).

The use of web-based interventions to achieve weight loss maintenance is a largely under-evaluated area. Meta-analyses suggest that web-based interventions achieve similar levels of weight loss maintenance to face-to-face interventions, and less weight is regained in comparison with no intervention.

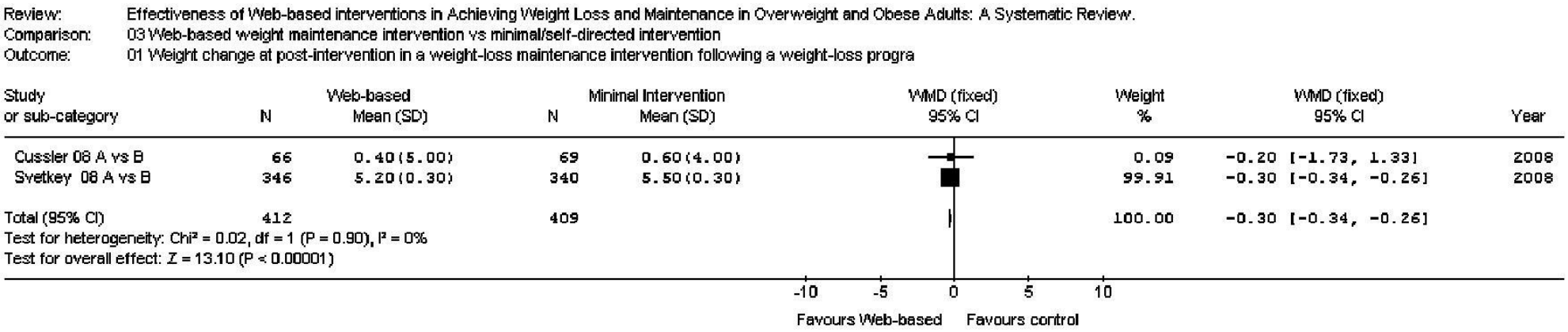


Figure 3.4 A meta-analysis of two RCTs comparing web-based weight loss maintenance interventions with a control group.

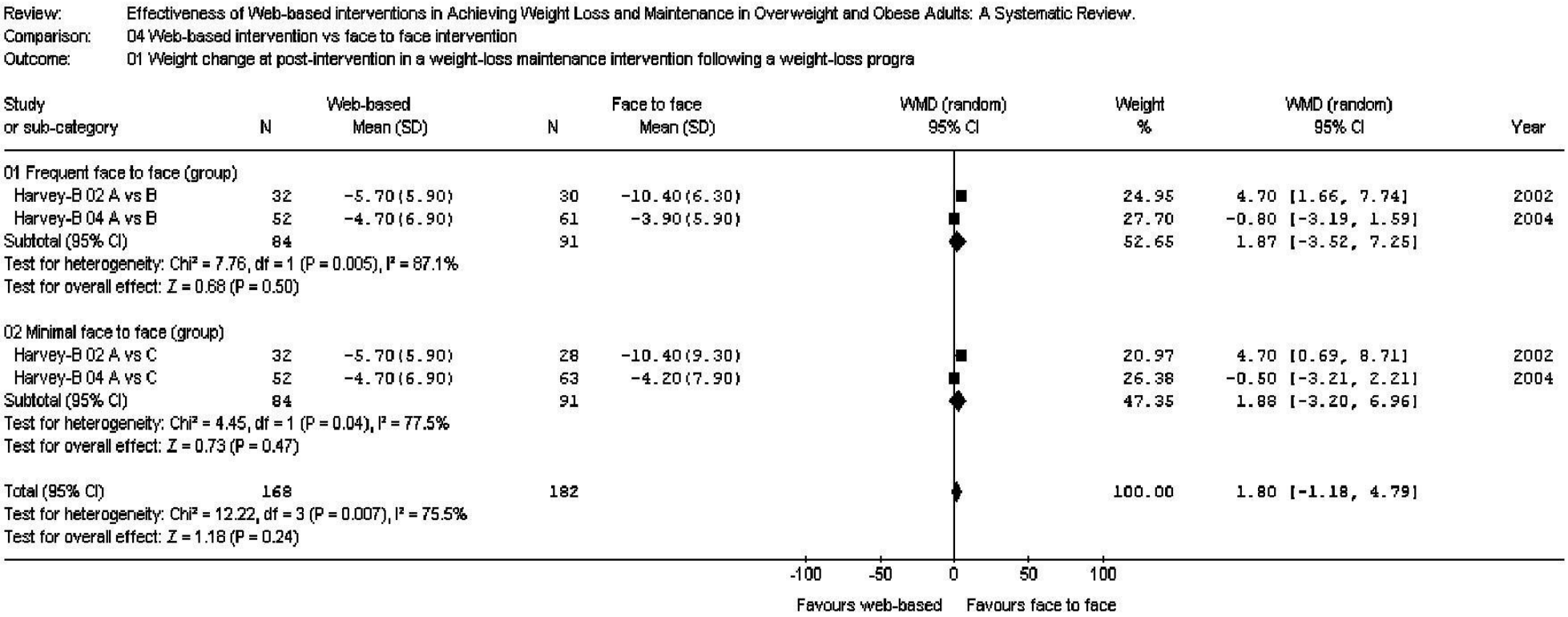


Figure 3.5 A meta-analysis of two RCTs comparing web-based weight loss maintenance interventions with face-to-face group based interventions

3.3.5 Components of web-based interventions potentially associated with effectiveness

Sixteen studies explored outcomes related to the usage of the web-based intervention, this included number of log-ins, usage of self-monitoring tools, peer and social support provision, attendance at online chat groups and posts to bulletin boards (Table 3.3)

Table 3.3 Compliance with web-based intervention components in weight loss and weight loss maintenance studies

Study	Data collected	Results	Significant difference between groups	Correlation with weight change	Correlation with attrition
Overall website usage					
Weight loss interventions					
Carr *et al.* 2008 (48)	Number of log-in days	a) Average of one every 11th day	N/A	NR	NR
Gold *et al.* 2007 (25)	Median number of log- in days at 6- and 12-months	a) n=62, 0–6-months: 47 (25–65), 6–12-months: 14 (8–23) b) n=62, 0–6-months: 193 (120–309), 6-12-months: 90 (21–154)	Yes: higher in group B between 0–6-months and 6–12-months (p<0.001)	Yes: both groups between 0–6-months, but not at 6–12-months (group A p <0.003; group B p<0.001)	NR
McConnon *et al.* 2007 (45)	Mean number of log-ins from 0–12-months	a) n=111, 15.8 (15.2)	N/A	NR	NR
Micco *et al.* 2007 (46)	Mean number of log-ins at 6- and 12-months	a) n=62, 0–6-months: 223 6–12-months: 99 b) n=61, 0–6-months 206, 6–12-months: 90	No	NR	NR
Mobley 2006 (41)	Mean number of log-ins at 3-months	b) n=43, 17 (37) d) n=43, 17 (30)	NR	No	NR
Tate *et al.* 2006 (43)	Median number of log-ins at 6-months	a) n=67, 34. b) n=61, 20 c) n=64, 32.5	Yes: groups A and C greater than group B over 6-months (p=0.03)	Yes: across groups (p=0.04)	NR
Tate *et al.* 2003 (39)	Mean number of log-ins at 3-, 6-, 9- and 12-months	Reported in graph	Yes: higher in group B at 3-, 6-, 9- and 12-months (p<0.05)	Yes: groups A & B between 0- and 12-months (group A, p<0.001, group B p=0.003)	Yes: number of log-ins at 3-months lower among 12-month drop-outs

Study	Data collected	Results	Significant difference between groups	Correlation with weight change	Correlation with attrition
Tate *et al.* 2001 (36)	Mean number of log-ins at 3- and 6-months	a) n=45, 0–3-months 8.5 (10.4) 3–6-months 1.0 (3.0) b) n=46, 0–3-months: 19 (10.9), 3–6-months: 6.8 (6.2)	Yes: higher in group B at 3- and 6-months (p<0.001)	Yes: groups A & B between 0 and 6 months. (group A p=.03, group B p=0.003)	NR
Webber 2007b (134)	Mean number of log-ins at 16-weeks	a) n=33, 39.7 b) n=33, 42.8	No	Yes: groups A & B (p<0.01)	NR
Womble *et al.* 2007 (24)	Mean number of log-ins at 12-weeks	b) n=23, 17.7 (21.1)	N/A	No	NR
Weight loss maintenance interventions					
Svetkey *et al.* 2008 (50)	Mean number of log-ins at 30-months	b) n=? Average log-in once per week and one website contact for 77% of the months	N/A	NR	NR
Self-monitoring					
Weight loss interventions					
Carr *et al.* 2008 (48)	Completion of online journal activities	a) Average of 13 out of 44 completed	N/A	NR	NR
Gold *et al.* 2007 (25)	Median number of self-monitored weights at 6- and 12-months	a) n=62, 0–6-months: 16 (8–22), 6–12-months: 8 (2–13) b) n=62, 0–6-months: 24 (20–25), 6–12-months: 8 (2–12)	Yes: higher in group B between 0–6-months (p=0.002) No: between 6–12-months	Yes: both groups between 0–6-months, but not at 6–12-months (group A p <0.001; group B p <0.001)	NR
Polzein *et al.* 2007 (47, 136)	Mean number of meals logged at 12-weeks	b) n=19, 261.4 (128.6) c) n=18, 53.9 (39.8)	No	Yes: groups B and C (p<0.01)	NR
	Mean number of diaries with kcal logged at 12-weeks	a) n=19, 6.5 (3.8) b) n=19, 3.5 (3.1)	No	Yes: group B (p<0.001)	NR
	Mean number of diaries with exercise logged at 12-weeks	a) n=19, 7.2 (3.7) b) n=19, 3.9 (3.1)	No	Yes: group B (p<0.001)	NR
Tate *et al.* 2006 (43)	Mean number of weeks diary submitted at 6-months	b) n=61, 11.4 (9.2) c) n=64, 17.2 (8.7)	Yes: group C greater than group B (p=0.000)	Yes: groups B & C (p<0.001)	NR
Webber 2007b (134)	Mean number of diaries completed per week at 16-weeks	a) n=33, 9.1 b) n=33, 7.5	No	Yes: groups A & B (p<0.01)	NR

Study	Data collected	Results	Significant difference between groups	Correlation with weight change	Correlation with attrition
Womble *et al.* 2004 (24)	Mean number of days diary completed at 52-weeks	a) n=24, 29.0 (35.3) b) n=23, 18.3 (21.7)	No	Yes: across groups week 16 (p <0.01) and 52 (p<0.006)	NR
Weight loss maintenance interventions					
Cussler *et al.* 2008 (49)	Mean number of times diet logged at 12-months	a) n=66, 53.4 (62.3)	N/A	No	NR
	Mean number of weights logged at 12-months	a) n=66, 26.9 (19.9)	N/A	No	NR
	Mean number of times physical activity logged at 12-months	a) n=66, 67.5 (76.3)	N/A	No	NR
Harvey-Berino *et al.* 2004 (40)	Mean number of diaries submitted at 12-months	a) n=77, 18.6 (13.2) b) n=77, 11.6 (13.2)	Yes: higher number in group A (p<0.01)	Yes: both groups (p<0.01)	NR
Harvey-Berino *et al.* 2002a (38)	Proportion of possible records diaries submitted at 12-months	a) n=40, 19% b) n=41, 22%	No	NR	NR
Harvey-Berino *et al.* 2002b (37)	Proportion of possible records diaries submitted at 12-months	a) n=? 38% (29) b) n=? 45% (31)	No	NR	NR
Social support					
Weight loss interventions					
Gold *et al.* 2007 (25)	Perceived Social Support Scale at 6- and 12-months	a) n=62, 6-months: 3.5 (2.9), 12-months: 2.8 (2.9) b) n = 62, 6-months: 6.7 (3.2), 12-months: 7.6 (2.7)	Yes: higher for group B at 6- and 12- months (p<0.001)	NR	NR
Weight loss maintenance interventions					
Harvey-Berino *et al.* 2004 (40)	Perceived Social Support Scale at 6- and 12-months	NR	No	NR	NR
	Mean number of peer contacts at 12-months	a) n=77, 27.1 (58.2) b) n=77, 4.9 (17.4)	Yes: higher in group A (p <0.01)	NR	NR
Harvey-Berino *et al.* 2002a (38)	Mean number of peer contacts at 12-months	a) n=40, 6.8 (13.5) b) n=41, 0.04 (0.43)	Yes: higher in group A (P = 0.02)	NR	NR
Harvey-Berino *et al.* 2002b (37)	Mean number of peer contacts at 22-weeks	a) n=? 4 (4) b) n=? 15 (28)	No	NR	NR
Attendance at online meetings/chat sessions					
Weight loss interventions					

Study	Data collected	Results	Significant difference between groups	Correlation with weight change	Correlation with attrition
Gold *et al.* 2007 (25)	Median number of facilitated meetings attended at 6- and 12-months	a) n=62, 0–6-months: 1 (0–3), 6–12-months: 0 (0–0) b) n=62, 0–6-months: 21 (19–23), 6–12-months: 11 (6–14)	Yes: higher number in group B between 0–6-months and 6–12-months ($p < 0.001$)	Yes: group B only between 0–6 months ($P < 0.001$)	NR
Weight loss maintenance interventions					
Harvey-Berino *et al.* 2004 (40)	Mean number of group meetings/chat sessions attended at 12-months	a) n=77, 10 (5.1) b) n=77, 7.7 (5.3)	Yes: higher attendance in group B (p=0.02)	Yes: both groups ($p < 0.01$)	NR
Harvey-Berino *et al.* 2002a (38)	Proportion of possible group meetings/chat sessions attended at 12 months	a) n = 40, 39% b) n = 41, 54%	Yes: higher in group B (p=0.04)	NR	NR
Bulletin boards/forums					
Weight loss interventions					
Webber 2007b (134)	Mean number of posts at 16-weeks	a) n=33, 7.2 b) n=33, 2.4	Yes: greater number in group A (p=0.03)	Yes: groups A & B (group A $p < 0.05$, group B p=0.068)	NR
Weight loss maintenance interventions					
Cussler *et al.* 2008 (49)	Mean number of posts at 12-months	a) n=66, 12.9 (19.7)	N/A	No	NR

Abbreviations: N/A, not applicable; NR, not reported; ?, sample size unclear.

Eleven studies tracked website usage through log-ins (24, 25, 36, 39, 41, 43, 45, 46, 48, 50, 134). Most studies reported results as mean or median log-ins, making comparisons between studies difficult due to varying intervention lengths. Four studies reported statistically significant differences in number of log-ins between groups (25, 36, 39, 43), three of which demonstrated higher log-ins in a web-based intervention with behavioural therapy (25, 36, 39). Seven studies investigated associations between weight loss and number of log-ins (24, 25, 36, 39, 41, 43, 134), with five studies showing a greater number of log-ins was associated with increased weight loss (25, 36, 39, 43, 134). One study explored associations between number of log-ins and attrition, and found that the initial number of log-ins were significantly lower among those who dropped out by 12-months compared with those that completed the intervention (39).

Ten studies measured participants' usage of self-monitoring tools in the form of online diaries to record weight, food and drinks consumed and/or physical activity undertaken (24, 25, 37, 38, 40, 43, 47-49, 134). Results were not reported in a way that allowed comparisons among studies. Significantly higher levels of self-monitoring were reported

in a web-based intervention with behavioural therapy, compared with a commercially available web-based program (25); web-based intervention with human email counselling compared with a web-based intervention with automated email counselling (43); web-based intervention compared with a face-to-face intervention (40). Five weight loss intervention studies (25, 38, 43, 47, 134) and two weight loss maintenance studies (40, 49), explored correlations between weight change and level of self-monitoring with six studies reporting a significant correlation between the two (24, 25, 40, 43, 47, 134). No studies investigated the relationship between attrition and level of self-monitoring.

Four studies explored the level of peer/social support provided, with two measuring perceived social support (25, 40), and three the number of peer support contacts (37, 38, 40). Gold *et al.* showed higher perceived social support among participants of a web-based intervention that included behavioural therapy compared with a commercially available website (25). Two studies reported a significantly higher number of peer contacts in a web-based only intervention, compared with face-to-face (37, 38). No studies investigated associations between the level of social support and weight change or attrition.

Four studies collected data in relation to attendance at online meetings or chat sessions (25, 37, 38, 40). Three studies demonstrated significantly higher attendance levels in face-to-face groups compared with web-based group (37, 38, 40). Gold *et al.* found higher attendance at group meetings in a web-based behavioural therapy program, compared with a commercially available website (25). Two studies demonstrated a significant correlation between attendance at group meetings and weight change (25, 40). No studies investigated the relationship between attrition and attendance at online meetings or chat sessions.

Two studies looked at number of posts to website bulletin boards (49, 134). Webber *et al.* found a greater number of bulletin board posts in a web-based program with minimal motivational interviewing compared with a web-based intervention with enhanced motivational interviewing. They also demonstrated a positive correlation between the number of posts and increased weight loss (134). No studies investigated the relationship between attrition and posts to website bulletin boards.

Therefore, of the studies that examined the association, most found that the number of log-ins, self-monitoring occasions, chat room attendances or bulletin board posts were associated with greater weight loss or weight loss maintenance. Only one study explored the association between attrition rates and website usage.

Data were extracted in relation to the features of each web-based intervention for the 24 different web-based interventions described (Table 3.4). The majority of interventions included generic education material (n=22), a chat room or forum (n=16) and emails (n=17). All but two web-based intervention arms incorporated self-monitoring, of which 13 provided feedback to participants on their self-monitoring of weight, eating, and/or activity. Less common features were individualised education material (n=3), and specific diet (n=4) or activity plans (n=5) for participants to follow. The number of features incorporated in the web-based interventions varied from one to 10 features, with seven of the intervention arms having five features, nine had less than five and eight had greater than five. Therefore, due to the diversity of the intervention comparisons within studies, it is difficult to compare the effectiveness of the interventions by intervention intensity. Each of the meta-analyses previously explored included two or three studies. Thus, a sub-group analysis exploring differences in weight change based on intervention intensity is not feasible.

3.4 Discussion

This systematic review develops the evidence base in the area of web-based interventions for weight loss and weight loss maintenance. An additional 12 studies are included here, which were not part of the previous review by Saperstein *et al.* that included just six studies (27). Five of the additional studies are included due to the addition of weight loss maintenance interventions in this review, while seven have been published since 2006. These findings demonstrate the increased research interest and activity in the area, with the number of research articles more than doubling in less than 2 years.

Overall, of the seven studies (24, 25, 39, 40, 42, 43, 47) with percentage weight change data available, only four studies could be defined as effective (25, 40, 43, 47). The majority of studies did not report percentage weight change. Therefore, we cannot determine the true number of effective web-based interventions. We also cannot conclude absolutely that there is no difference in weight loss between web-based and control groups due to the heterogeneity identified in the meta-analysis. Despite demonstrating significantly greater weight change in web-based weight loss maintenance interventions compared with controls further research is required as only two studies were included in the meta-analysis. Furthermore, the meta-analysis results also suggest that web-based interventions achieve similar weight loss maintenance to face-to-face programs, but due to heterogeneity of studies this is not conclusive.

Table 3.4 Web-based intervention features

Study	Group	General info	Individualised info	Goal setting	Self-monitoring (feedback)	Self-monitoring (no feedback)	PA plan	Diet plan	Chat room	Online meeting	Professional email	Buddy	Email	Total no. of features
Weight loss interventions														
Carr *et al.* 2008 (48)	A	✓	✗	✓	✓	✗	✓	✗	✗	✗	✗	✓	✗	5
Gold *et al.* 2007 (25)	A	✓	✗	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	9
	B	✓	✗	✓	✗	✓	✗	✗	✓	✓	✓	✗	✗	6
McConnon *et al.* 2007 (45)	A	✓	✓	✓	✗	✓	✗	✗	✗	✗	✗	✗	✓	5
Micco *et al.* 2007 (46)	A B	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓	9
Mobley 206 (41)	C D	✓	✗	✓	✗	✓	✗	✗	✗	✗	✗	✗	✓	4
Polzein *et al.* 2007 (47, 136)	B C	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	1
Rothert *et al.* 2006 (42)	A	✓	✓	✗	✗	✗	✓	✓	✗	✗	✗	✓	✓	6
	B	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
Tate *et al.* 2006 (43)	A	✓	✗	✗	✓	✗	✗	✗	✗	✗	✗	✓	✓	4
	B	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✓	5
	C	✓	✓	✗	✗	✓	✗	✗	✓	✗	✓	✓	✓	7
Tate *et al.* 2003 (39)	A	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	4
	B	✓	✗	✗	✗	✓	✗	✗	✓	✗	✓	✗	✓	5
Tate *et al.* 2001 (36)	A	✓	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	2
	B	✓	✗	✗	✗	✓	✗	✗	✓	✗	✓	✗	✓	5
Webber 2007 (134)	A	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	3
	B	✓	✗	✗	✓	✗	✗	✗	✓	✓	✗	✗	✗	4
Womble *et al.* 2004 (24)	A	✓	✗	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓	9
Weight loss maintenance interventions														
Cussler *et al.* 2008 (49)	A	✓	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✓	4
Harvey-Berino *et al.* 2004 (40)	A	✓	✗	✗	✗	✓	✗	✗	✓	✓	✓	✗	✓	6
Harvey-Berino *et al.* 2002a (38)	A	✓	✗	✗	✗	✓	✗	✗	✓	✓	✓	✗	✓	6
Harvey-Berino *et al.* 2002b (37)	A	✗	✗	✗	✗	✓	✗	✗	✓	✓	✓	✗	✓	5
Svetkey *et al.* 2008 (50)	B	✓	✗	✓	✓	✗	✗	✗	✓	✗	✗	✗	✓	5
Total per feature		**22**	**3**	**8**	**9**	**13**	**5**	**4**	**16**	**8**	**8**	**7**	**17**	

✓ Includes feature ✗ Does not include feature. General info: generic information/education/lessons; Individualised info : individualised information/education/lessons; Goal setting: setting of weight loss related goals; Self-monitoring (no feedback): tool to monitor weight, diet and physical activity provided; Self-monitoring (feedback): tool to monitor weight, diet and physical activity provided, if completed feedback provided; PA plan: physical activity plan or prescription (e.g. energy expenditure target, ideas for exercise); Diet plan: diet plan or prescription (e.g. calorie target, menu plans); Chat room: chat room, forums or bulletin boards; Online meeting: professionally facilitated online meetings; Professional email: ability to contact health professional via email; Buddy system: linking members to other members with similar goals; Email: ability to email other members.

Saperstein *et al.* concluded that a critical component of web-based weight loss programs is the personalisation achieved through feedback or tailored information (27). The meta-analysis suggests that web-based weight loss interventions with enhanced behavioural features such as counselling and individualised feedback are more effective at achieving weight loss at post-intervention than web-based programs with education alone. However, despite the homogeneity of these results only three studies were included in the analysis, all of which were from the same research groups, which questions the external validity of the analysis. No studies were identified that explored the effect of enhanced web-based interventions on weight loss maintenance; therefore research is also warranted in this area.

The overall quality of included studies was moderate with study design potentially influencing effectiveness. To improve the quality and reporting of studies we suggest future studies consult the CONSORT statement (137). Recent RCTs of behavioural weight loss programs are on average 31.4 weeks in length, follow-up participants for 41.8 weeks and have 28 participants, of which 21.2% drop-out (90). The average intervention length for the studies in this review was 37.5 weeks. However, the intervention length of four studies (42, 47, 48, 134) was less than the standard behavioural treatment intervention length of 16-weeks (90). Furthermore, the long-term impact of web-based programs remains unknown due to the lack of follow-up beyond the intervention. The mean number of participants across studies was 316.7, with only one study including a small number of participants (n=20) (134). Retention rates within the intervention period were less than 80% for many interventions (n=9) (24, 25, 36-38, 40-42, 45, 48). Moreover, two of the three ineffective studies had retention rates less than 60% (36, 40), suggesting that the high attrition rates has impacted the ability of the studies to detect change. Therefore, it is recommended that future RCTs explore strategies to improve retention rates, ensure interventions are of an appropriate length and follow-up participants for at least 1-year post intervention to increase the likelihood of detecting weight and behaviour change.

A key component of eHealth interventions, such as web-based programs, is ensuring ample use of the technology (both frequency and duration) so each participant receives an ‘optimal dose’ (28). The review demonstrates that the number of log-ins, self-monitoring occasions, chat room attendances and bulletin board posts were associated with greater weight loss or weight loss maintenance in most, but not all, studies that have examined this association. There are also some findings to suggest that lower initial intervention usage is associated with attrition. However, most studies reported findings as an average number of contacts with a particular feature, therefore not

allowing comparability between studies, and making it difficult for the reader to ascertain compliance with the intervention over time. Furthermore, the studies were not designed to determine the impact of each feature on weight loss or weight loss maintenance, so these associations are not cause-and-effect. Therefore, future RCTs or longitudinal studies should report usage as a proportion of possible or expected contacts with the particular web-feature and aim to ascertain the ultimate dose required to achieve satisfactory weight loss or maintenance, while maintaining adequate attrition rates.

The review demonstrates the diversity in the number and type of components featured in web-based interventions. This highlights the need for succinct research questions and detailed intervention descriptions to allow readers to truly understand the components of the interventions being compared. It also highlights the importance of interpreting the meta-analysis results with caution due to this additional potential source of heterogeneity.

The definition of 'effectiveness' is limited as it does not take into consideration other key indicators of success such as waist circumference or percentage body fat. However, given the low number of studies that reported percentage weight change, it is unlikely that a definition utilising body composition would be more robust. This highlights the need for a consistent definition of effective weight loss and weight loss maintenance to be adopted by researchers. Such a definition would allow for greater comparability between studies and meta-analysis of results.

3.5 Conclusion

3.5.1 Implications for practice

Web-based weight loss and weight loss maintenance interventions have the potential to achieve outcomes similar to other lifestyle treatment options. However, while there is emerging evidence of effectiveness, we cannot currently recommend which components of web-based interventions are essential to enhancing weight loss within treatment for overweight and obesity.

3.5.2 Implications for researchers

The evidence in relation to the effectiveness of web-based interventions in achieving weight loss and weight loss maintenance remains uncertain, but is more convincing than in previous reviews. Future research in the area should prioritise well-designed efficacy trials comparing web-based interventions with the traditional methods of

delivering lifestyle interventions (e.g. individual and group-based counselling) or to waiting list controls. In addition, studies should be designed to determine which components of web-based interventions are critical to achieving efficacious weight loss and/or weight loss maintenance, including determination of an optimal usage or intervention dose. To ensure high-quality research in the area, strategies to improve retention rates and engagement with the web-based intervention (e.g. through email reminders, telephone prompts or via enhanced program features) should be further explored. In order to facilitate future systematic reviews and meta-analyses of program effectiveness all studies should report participants mean percentage weight change. Finally, to address the gap in long-term follow-up of participants' studies need to report results up to at least 1-year post intervention and ideally longer.

Chapter Four: Participant characteristics and reach of a commercial web-based weight loss program

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The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 6). Permission to reproduce the text and figures from the manuscript in this thesis has been granted by the publishers.

4.1 Introduction

In Australia the 2007-08 National Health Survey demonstrated a combined prevalence of overweight and obesity of 61% among Australian adults (2), with specific groups more likely to be overweight or obese. This includes men, as well as those aged 65 to 74 years (2), those with lower education levels, low income households with a disadvantaged socioeconomic status, and residents of rural and remote areas (138).

Given the large number of overweight and obese individuals, treatment options that have the ability to be widely disseminated in a cost-effective manner, and that can reach those most in need of receiving treatment, need to be developed. Web-based weight management programs have the potential to reach a large number of people, especially in areas where access to other health-care services may be restricted (139, 140).

In Australia, 72% of households have access to the Internet (103). Individuals who sign up for web-based programs are able to access treatment information and support 24 hours a day, 7 days a week and at a time of day that is most suitable to them (26, 28, 109, 110). Internet programs are also potentially cost-effective to the user, because of the removal of travel time and costs, as well as the possibility of lower enrolment fees because the cost of maintaining a web-based program could be lower than other mediums (27, 108-110). The anonymity offered by the Internet also allows those who may normally be too timid to seek treatment to participate (26-28, 108). However, a 'digital divide' still exists with lower Internet access rates in rural and remote areas, in households with lower weekly incomes and among the older population aged greater than 65 years (103).

The Internet is becoming more recognised for its potential to provide innovative behaviour change interventions (26). Our recent systematic review of web-based weight management interventions concluded that although some interventions produce significant weight change, there is currently not enough evidence to determine their overall effectiveness (Chapter 3). The review also highlighted the increased research activity in this area, with the number of published research articles doubling from 2006 to 2008. However, little is known about the profile of individuals who access web-based interventions, as a result of few real-world studies being undertaken (88). We do not know who accesses web-based weight management programs, and therefore whether they reach at-risk population groups.

SP Health Co. offers a web-based weight loss platform that is commercially available as The Biggest Loser Club (http://www.biggestloserclub.com.au). The 12-week program includes best practice weight management strategies such as goal setting, social support and self-monitoring of diet, physical activity and anthropometry. The cost of the program in 2007/2008 ranged from $AU16.50 to $AU79.95 per month, which is dependent on the number of months a participant subscribed. The program aims to reach Australians aged 18 to 75 years, with a BMI≥22, who are trying to lose weight or prevent weight gain, and who have access to the Internet. The participants must also be willing to pay the subscription fees. The Biggest Loser Club is primarily marketed through 'The Biggest Loser Australia', a reality television program that appeals predominantly to women aged 18 to 49 years. The primary aim of the present study is to describe the characteristics of participants who enrolled in the SP Health Weight Loss Platform. The secondary aim is to assess the reach of the program through investigation of the size of the target population, proportion of the target population enrolled in the program and how representative the participants are of the target population, as per the reach component of the RE-AIM framework (111).

4.2 Methods

Participants enrolled in the SP Health Weight Loss Platform from August 15th 2007 to May 31st 2008. To be eligible to join participants must be aged 18 to 75 years, and have BMI ≥22, based on self-reported height and weight. Participants who received access to the program but did not pay (e.g. free promotional program trials) were excluded from the analysis.

Participants enrolled by accessing the website and completing an online enrolment form (Appendix 2), which included questions regarding anthropometrics (weight, height and waist circumference), demographics (age, gender, ethnicity and postcode), reasons for trying to lose weight and current dietary and physical activity behaviours (number of days they exercise, eating habits and reasons for eating). Only weight, height, age, gender, postcode and ethnicity were mandatory questions. SP Health Co. extracted stored data, which was de-identified and provided to the researchers. Ethics approval for the study was obtained from the relevant Human Research Ethics Committee.

Data collected from the enrolment survey were used to describe participants' characteristics. Additional descriptors were created as follows:

- Weight and height were used to calculate BMI (weight (kg)/height $(m)^2$), and categorised using the WHO BMI classification of 18.50–24.99 kg/m^2 (Normal), 25.00–29.99 kg/m^2 (Pre-obese), 30.00–34.99 kg/m^2 (Obese Class I), 35.00–39.99 kg/m^2 (Obese Class II) and ≥40 kg/m^2 (Obese Class III) (7).
- Disease risk based on waist circumference was determined using the WHO cut-points of ≥94 centimetre (cm) for men and ≥80 cm for women (increased risk), and ≥102 cm for men and ≥88 cm for women (substantially increased risk) (7).
- Postcodes were assigned an Index of Relative of Socio-economic Advantage and Disadvantage (IRSAD) tertile, as an indicator of socioeconomic status. There are 10 tertiles of equal distribution, whereby 1 equates to the most disadvantage and 10 the most advantage (141).
- Postcodes were assigned an Accessibility/Remoteness Index of Australia (ARIA), to classify how remote the area in which the participant lived was within Australia (Major city 0 to ≤0.2, Regional: >0.2 to ≤5.92, Remote Australia >5.92) (142).
- Reasons for weight loss were classified as health-related (e.g. doctor recommended, health scare) and non-health-related reasons (e.g. to look good, for love life). Participants were categorised as either having 'one or more health-related reason' or 'no health-related reason' for weight loss.

Data analysis was undertaken using StataIC 10 (StataCorp LP, College Station, TX, USA). Participant baseline characteristics are described as means (SD) for continuous variables, and percentages for categorical variables. Sex and BMI group differences were tested using independent *t*-tests or ANOVA for continuous variables and χ^2-tests for categorical variables. The significance level was set at $p < 0.05$.

Program reach was assessed using the 'reach' (R) component of the RE-AIM framework, a model for assessing the reach, efficacy, adoption, implementation and maintenance of public health interventions (111). The target population were operationally defined as any Australian aged 18 to 75 years, with a BMI of ≥22, who was using a commercial program to lose or maintain weight and had access to the Internet. The target group size was estimated from available population data. The data that were most comparable to the time the participants enrolled in the SP Health Weight Loss Platform (2007/2008) were used. Australian population estimates from June 2007(143) were used to approximate Australia's adult population size. The proportion of Australians classified as normal weight, overweight and obese, by age and sex, were calculated from 2007 to 2008 National Health Survey data (2). It was assumed that 50% of the Australian population in the normal weight range have a BMI

≥ 22. The number of Australians with any Internet access was derived from data collected by the Australian Bureau of Statistics (104). The number of Australian adults who access commercial programs was estimated from published data. No data were available for Australia; therefore, data from the USA were used (13% for women and 5% for men) (127). The potential target group size was calculated by first multiplying the number of Australian adult residents by the proportion of people with Internet access, and then by the proportion of people who access commercial weight loss programs. The proportion of the target population who enrolled was calculated by dividing the number of SP Health Weight Loss Platform participants by this target population. Results are presented as totals and by age, sex, and BMI categories.

The representativeness of the target population was investigated by comparing the participant's demographic characteristics (age, sex, socioeconomic status and remoteness), to similar data from national health (2, 138) and Internet access surveys (104), as well as results from other studies describing the characteristics of commercial weight loss program participants (121, 122, 124, 126). Because of the different methodologies used to collect the data, and therefore limited comparability, no statistical analysis could be undertaken and results are presented in a narrative summary.

4.3 Results

The sample consisted of 11341 participants (87% women, n=9810). Their characteristics are described in Table 4.1, which highlights that most were obese (60%, n=6756), with a waist circumference that placed them at a substantially increased risk of disease (79%, n=6134). They were predominantly Anglo-Saxon (60%, n=6791), of the highest levels of socioeconomic status (386% IRSAD 9–10 decile, n=4199) and from major cities within Australia (76%, n=8452).

Gender differences in participants' baseline characteristics are described in Table 4.1. Men had significantly higher BMIs compared with women (p<0.001) and higher proportions were at a substantially increased risk of disease based on waist circumference measures (p<0.001). A significantly higher proportion of men than women reported poor lifestyle behaviours such as exercising less than once per week (p <0.001), frying foods, using butter in cooking, skipping meals and drinking full sugar soft drinks (p <0.001) (Table 4.1). A significantly higher proportion of men reported at least one health-related reason for wanting to lose weight (p <0.001).

Table 4.1 Characteristics of SP Health Weight Loss Platform members at enrolment by sex and BMI

	Total n=11341	Sex		BMI			Significance (*p*)	
		Male n=1531	Female n=9810	Normal weight n=956	Overweight n=3629	Obese n=6756	Sex	BMI
Age (years)								
Mean (SD)	35.6 (9.5)	35.6 (9.6)	35.6 (9.5)	32.5 (8.7)	34.9 (9.2)	36.4 (9.6)	0.99[f]	<0.001[h]
18–25 years (%)	13.1	12.2	13.2	19.7	14.8	11.2	0.82[g]	<0.001[g]
25–35 years (%)	37.8	38.3	37.7	47.2	38.8	36.0		
35–45 years (%)	32.7	33.1	32.7	24.2	32.2	34.2		
45–55 years (%)	12.8	12.6	12.9	6.7	11.6	14.4		
55–65 years (%)	3.2	3.5	3.1	2.0	2.4	3.8		
65–75 years (%)	0.4	0.3	0.4	0.2	0.3	0.5		
BMI (kg/m^2)[a]								
Mean (SD)	32.6 (6.7)	34.2 (5.9)	32.4 (6.7)	23.8 (0.8)	27.6 (1.4)	36.6 (5.7)	<0.001[f]	<0.001[h]
Normal weight (%)	8.4	0.7	9.6	NA	NA	NA	<0.001[g]	NA
Pre-obese (%)	32.0	24.7	33.1					
Obese Class I (%)	29.0	38.5	27.5					
Obese Class II (%)	17.0	20.8	16.4					
Obese Class III (%)	13.6	15.4	13.4					
Waist circumference (cm)[b]								
Mean (SD)	101.4 (15.7)	114.7 (15.2)	99.4 (14.9)	81.7 (7.4)	91.5 (9.1)	109.6 (13.8)	<0.001[f]	<0.001[h]
Increased risk (%)	93.3	95.8	93.0	58.1	90.9	99.6	0.001[g]	<0.001[g]
Substantially increased risk (%)	79.0	83.1	78.4	20.5	62.0	96.6	0.001[g]	<0.001[g]
Ethnicity								
Anglo-Saxon (%)	59.9	62.3	59.5	57.5	59.1	60.6	<0.001[g]	0.00[g]
European (%)	14.6	16.2	14.6	14.1	15.1	14.4		
Other (%)	3.5	5.4	3.5	5.1	3.4	3.4		
Did not wish to respond (%)	22.0	16.1	22.0	23.0	22.4	21.6		
Socioeconomic status (IRSAD)[c]								
1–2 (%)	5.8	5.4	5.9	4.4	4.6	6.7	<0.001[g]	<0.001[g]
3–4 (%)	9.2	9.0	9.3	6.8	7.1	10.7		
5–6 (%)	18.1	17.8	18.2	13.8	16.1	19.8		
7–8 (%)	29.3	29.8	29.2	25.9	29.0	29.9		
9–10 (%)	37.6	38.0	37.5	49.2	43.3	32.8		

Remoteness (ARIA)[d]								
Major city (%)	75.6	81.0	74.8	77.8	77.6	74.3	<0.001[g]	0.002[g]
Regional (%)	23.0	18.1	23.8	20.8	21.3	24.2		
Remote (%)	1.4	0.9	1.5	1.4	1.2	1.5		
Days of planned exercise[e]								
0–1 days (%)	50.2	54.3	49.6	38.4	41.9	56.3	<0.001[g]	<0.001[g]
2–3 days (%)	31.3	27.7	31.9	36.2	36.5	27.8		
4+ days (%)	18.5	18.0	18.6	25.5	21.6	15.9		
Eating habits								
Fry foods (%)	37.7	51.9	35.5	29.9	33.2	41.2	<0.001[g]	<0.001[g]
Use butter in cooking (%)	35.7	40.0	35.1	35.8	33.7	36.9	<0.001[g]	0.01[g]
Drink full sugar soft drinks (%)	29.3	42.8	27.2	24.9	26.0	31.7	<0.001[g]	<0.001[g]
Skip meals (%)	52.5	63.0	50.9	43.6	47.5	56.5	<0.001[g]	<0.001[g]
Drink tea or coffee with sugar (%)	43.7	49.3	42.9	44.5	44.3	43.3	<0.001[g]	0.53[g]
Eat breakfast (%)	73.7	63.5	75.2	80.0	77.4	70.8	<0.001[g]	<0.001[g]
Use low fat products (%)	65.5	50.9	67.8	70.1	69.3	62.8	<0.001[g]	<0.001[g]
Keep snack foods in the house (%)	59.3	60.7	59.0	55.5	55.8	61.7	0.22[g]	<0.001[g]
Drink 6+ glasses of water a day (%)	41.0	35.9	41.8	43.0	42.5	39.9	<0.001[g]	0.02[g]
Reason for eating								
To ease emotional upset (%)	55.4	28.4	59.6	46.3	49.1	60.1	<0.001[g]	<0.001[g]
For the joy of it (%)	56.0	57.9	55.7	57.2	55.9	55.9	0.10[g]	0.73[g]
To reduce stress (%)	44.0	31.1	46.0	36.9	38.8	47.8	<0.001[g]	<0.001[g]
Out of boredom (%)	78.8	68.6	80.4	74.9	78.2	79.7	<0.001[g]	0.002[g]
Reason for weight loss								
One or more health-related reasons (%)	54.1	60.2	53.2	39.0	48.4	59.3	<0.001[g]	<0.001[g]

[a] n=11340; [b] n=7766; [c]n= 11306; [d]n=11174, [e]n=11175, [f]Two-sample *t*-test; [g] χ^2-test; [h]anova; Abbreviations: ARIA, Accessibility/Remoteness Index of Australia; BMI, body mass index; IRSAD, Index of Relative Socioeconomic Advantage/Disadvantage; NA, not applicable.

Table 4.1 also describes differences in participants' baseline characteristics by BMI classification group and shows that mean age was significantly different across BMI groups (p<0.001), with those in the obese category having the highest mean age (36.4 years). A higher proportion of obese participants were disadvantaged based on a higher prevalence of low IRSAD (1–6 decile, 37%, n=2477) or residing in regional and remote areas of Australia (26%, n=1713). Overweight and obese enrolees also reported lower exercise levels and poorer eating habits on enrolment compared with healthy weight participants. A higher proportion of obese participants were more likely to report eating to 'ease emotional upset' or 'to reduce stress', and to have health-related reasons for trying to lose weight (p<0.001).

The target population size and proportion of the target population who enrolled in the SP Health Weight Loss Platform between August 15th 2007 and May 31st 2008 are outlined in Table 4.2. It was estimated that 710681 Australians were 'eligible' to enrol in the SP Health Weight Loss Platform, of which 215354 were male and 495327 female. Approximately 1% of eligible men and 2% of eligible women enrolled in the program, with an overall participation rate of 2%. The highest overall participation rate was among obese 25 to 35 year olds (8%), followed by obese 18 to 25 year olds (6%). These two groups had the highest participation rates for both men and women, with female participation rates approximately twice as high as male rates in both groups. There were lower participation rates among those aged 55 to 75 years.

Table 4.2 Potential target group size and proportion of target group enrolled in the SP Health Weight Loss Platform

Age	BMI category	Potential target group size (n)[a]			Proportion of target group enrolled in SP Health Weight Loss Platform (%)[b]		
		Men	Women	Total	Men	Women	Total
18 to 25 years	Healthy	11709	30569	42278	0.0	0.6	0.4
	Overweight	12001	21939	33940	0.4	2.2	1.6
	Obese	4084	8992	13076	3.2	7.0	5.8
25 to 35 years	Healthy	11105	38332	49437	0.0	1.2	0.9
	Overweight	21668	36418	58086	0.7	3.4	2.4
	Obese	9317	22248	31565	4.6	9.0	7.7
35 to 45 years	Healthy	9527	41881	51408	0.0	0.6	0.5
	Overweight	24925	41390	66315	0.5	2.5	1.8
	Obese	15339	35173	50512	2.5	5.5	4.6
45 to 55 years	Healthy	7682	32346	40028	0.0	0.2	0.2
	Overweight	24213	44912	69125	0.2	0.9	0.6
	Obese	15808	35246	51054	1.0	2.3	1.9
55 to 65 years	Healthy	5397	18469	23866	0.0	0.1	0.1
	Overweight	17131	31021	48152	0.0	0.3	0.2
	Obese	11069	26821	37890	0.4	0.8	0.7
65 to <75 years	Healthy	2166	7242	9408	0.0	0.0	0.0
	Overweight	7831	12984	20815	0.0	0.1	0.0
	Obese	4382	9344	13726	0.1	0.3	0.2
Total		215354	495327	710681	0.7	2.0	1.6

[a] Number of Australian adult residents × % people with Internet access × % people in three BMI categories × % using a commercial program. [b] Number of SP Health Weight Loss Platform participants/target population.

The majority of program participants were classified as advantaged based on the IRSAD. Households in Australia, with higher income and educational attainment, as well as high skill workers have higher levels of Internet access (104). Higher overweight/obesity prevalence in Australia is found among those in the lowest levels of disadvantage (138). Other commercial programs report the majority of participants have higher family incomes (122, 124). The highest proportions of program participants are from major cities of Australia (82%). The highest levels of Internet access (66.2% of dwellings) in Australia are also in major cities (104), but there are lower levels of overweight and obesity in these areas (138).

The demographic characteristics of the target population are outlined in Table 4.3. In summary, SP Health Weight Loss Platform participants were predominantly female (86.5%). In Australia, a higher proportion of men, compared with women, are overweight and obese (63% vs. 48%) (138) There is no difference in overall Internet access, among men and women in Australia (104). Reported participation rates by men in commercial weight loss programs to date have been generally less than 5% (122, 124).

Most program participants were aged 25 to 44 years (70%). In Australia, those aged 55 to 64 years have the highest prevalence of overweight and obesity (67%), followed closely by the 65 to 74 years (67%) and 45 to 54 years (63%) age groups (2). Internet access in Australia is high (>70% of dwellings) for both sexes from age 18 to 55 years. After this time it decreases to as low as 22% in women aged 75 years or over (104). The average age or majority of participants in other commercial weight loss programs is generally greater than 40 years (121, 124).

4.4 Discussion

The present study provides a detailed description of the characteristics of more than 11000 individuals who enrolled in a commercial web-based weight loss program, over a 10-month period. The program attracted adults who were at high risk of obesity-related comorbidities, and who self-reported suboptimal eating and physical activity habits. Given the large number of enrolees with this relatively poor risk factor profile, a web-based weight management program has the potential to make an important contribution to public health.

Table 4.3 Summary of demographic characteristics of the potential target group for the SP Health Weight Loss Platform target population from available population data

		Overweight and obese Australians (2, 138)	Internet access in Australia[a] (104)	Commercial weight loss program participation (121, 122, 124, 126)
Gender	Men	40.9% Overweight 22.3% Obese	See below	<5%
	Women	28.0% Overweight 20.4% Obese	See below	>95%
Age	18 to 25 years	25.1% Overweight 9.1% Obese	79% Men 79% Women	Average age >40 years
	25 to 35 years	33.2% Overweight 16.5% Obese	74% Men 75% Women	
	35 to 45 years	33.7% Overweight 23.6% Obese	78% Men 81% Women	
	45 to 55 years	36.8% Overweight 26.1% Obese	77% Men 78% Women	
	55 to 65 years	38.5% Overweight 28.2% Obese	67% Men 63% Women	
	65 to 75 years	40.9% Overweight 25.6% Obese	47% Men 39% Women	
	>75 years	34.7% Overweight 15.9% Obese	28% Men 22% Women	
Socioeconomic status		*Index of disadvantage* Advantaged (5th Quintile): 35.2% Overweight, 13.2% Obese Disadvantaged (1st Quintile): 34.5% Overweight, 21.9% Obese	*Highest year of school completed* Year 12 or equivalent: 80.8% Did not go to school: 39.5% *Labour force status* Employed full time: 78.6% Not in labour force: 53.4% *Weekly household income* $1–$149: 45.0% $2000 or more: 86.0%	High family incomes
Remoteness	Major city	35.1% Overweight 16.7% Obese	66.2%	Not reported
	Inner regional	36.4% Overweight 19.5% Obese	57.7%	
	Outer regional	36.5% Overweight 23.0% Obese	54.6%	
	Remote		53.1%	

[a]Any Internet access.

The baseline characteristics of participants demonstrate that the program predominantly appeals to those aged 18 to 45 years. This is possibly due to the marketing of the platform to this age group through 'The Biggest Loser Australia' television program. However, it also demonstrates the potential for web-based obesity interventions as an important and viable treatment option for younger adults because of their higher Internet access rates (104). Therefore, web-based programs may provide an opportunity for younger adults to initiate obesity treatment early, and act as a preventative strategy to decrease the prevalence of obesity in older age groups.

Participation rates by men in other commercial programs are generally less than 5% (122, 124) whereas this program demonstrates an enrolment rate almost triple this. Furthermore, when participation rates from the target population were explored, we found that although women still had the highest participation rate, the difference between men and women was not as substantial. To date, men have reported not being interested in face-to-face weight loss programs and wanting flexible, convenient and individually designed programs (144). Therefore, our results suggest that web-based programs may have greater appeal for men compared with traditional face-to-face interventions. We found that men who enrolled in the web-based program had higher BMIs and waist circumferences, poorer eating and physical activity habits, and different reasons for eating and weight loss, compared with women. This highlights a unique opportunity to target men to engage in weight loss, who perhaps would not seek treatment otherwise (144).

The enrolees of the SP Health Weight Loss Platform were predominantly from major cities in Australia, and of moderate-to-high socioeconomic status. When compared with the demographics of the target group, we find this is not unexpected given that there are lower Internet access rates in households of lower socioeconomic status and in rural and remote areas (104). Furthermore, those of lower socioeconomic status may also have lower participation rates in commercial weight loss programs (122, 124). It has been hypothesised that web-based health promotion interventions may be able to reach people whose access to other health-care services may be restricted, for example, those of lower socioeconomic status and in rural and remote areas (26). While our data are unable to support this hypothesis, they do demonstrate that although only a moderate proportion of individuals of lower socioeconomic status enrolled in the web-based program, a high proportion of those who did, were often in the highest obesity-related risk category. Therefore, there may be opportunity to promote web-based weight loss programs to members of this population subgroup, as a feasible treatment option.

The present study applied the RE-AIM framework to assess program reach in a commercial data set. However, there are some limitations to the study methodology. The estimates of the target population size are based on readily available population data. Therefore, several assumptions had to be made. For example, it was assumed that the prevalence of commercial web-based program use is consistent across all forms of commercial weight loss programs, and that it is constant across age and BMI categories. In addition, it was assumed that the proportion of Australians utilising commercial weight loss program, is the same as the USA. These assumptions could

have a positive or negative impact on the estimated reach of the program. Furthermore, because of methodological differences the data used to assess representativeness are not directly comparable and were limited to a narrative summary. The study was also unable to capture all facets of reach, as outlined by the RE-AIM framework (111). This included the number of potential participants exposed to the recruitment and the number who responded to recruitment. It is unlikely, given the marketing of the web-based program through a television program that appeals to younger women, that the recruitment strategy reached a large proportion of men, or those aged over 50 years. Therefore, quantitative exploration of recruitment exposure could have further explained the age and sex disparities in enrolment. The study also did not assess the overall public health impact of the program as assessment of all elements of the RE-AIM framework (efficacy, adoption, implementation and maintenance) (111) was not conducted. This should be an area of interest for further research. Finally, the estimated program reach may be higher than other commercial web-based programs, as it was marketed through a popular television program. Therefore, this should be taken into consideration when comparing the results of the present study, with other commercial web-based weight loss programs. Despite these limitations, the study provides novel real-world data to characterise those who enrol in a web-based weight management program. It is unique to most other web-based intervention research, as it describes true commercial web-based program participants as opposed to volunteers who sign up for a research study. Therefore, the results are generalizable to the Australian population, specifically those who enrol in commercial weight loss programs, and can be used to demonstrate the potential reach of this treatment medium.

The results of the present study demonstrate that web-based weight management programs have the ability to attract a large number of individuals at risk of weight-related morbidity, as well as the ability to appeal to the ‘hard-to-reach’ groups such as men and younger clients, compared with other weight loss interventions. This highlights that there may be opportunities for health professionals, particularly Accredited Practising Dietitians to engage with web-based interventions. This is not only due to their appeal to clients but also as a means of coping with the high demand for obesity treatment services (145). Web-based weight management interventions could be used by health practitioners as the sole source of treatment or as an adjunct to group or one-on-one consultations. These are important considerations, as a recent editorial highlighted the need for health professionals, particularly Accredited Practising Dietitians, to take the lead in exploring opportunities to utilise web-based programs in

their practice (145). However, the ability of web-based interventions to achieve clinically important weight loss and weight loss maintenance in the long-term requires further evaluation, along with the ability of this treatment method to engage and retain participants. Therefore, a research and health-care priority should also be the development, evaluation and dissemination of cost-effective web-based weight management programs.

Chapter Five: Weight change in a commercial web-based weight loss program and its association with website use

This chapter was accepted for publication in 2011.

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The authors of the paper are Neve MJ, Morgan PJ and Collins CE. The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 7). Permission to reproduce the text and figures from the manuscript in this thesis has been granted by the publishers.

5.1 Introduction

As the prevalence of overweight and obesity among adults continues to increase across the world (146), the need for cost-effective programs that achieve clinically important weight loss and have a broad reach are urgently needed. However, at this time there is no universally effective method of weight management that assures long-term maintenance of lost weight (19, 90). Despite this many overweight and obese men (44%) and women (65%) report trying to lose weight (147), many of whom join commercial weight loss programs (112).

The most recent systematic review of major commercial weight loss programs concluded that there was inadequate evidence to recommend their use [5], and that further RCTs were required to provide evidence to support or refute the use of commercial weight loss programs (112). Although controlled trials are essential to demonstrate efficacy, the results may not always be generalizable to typical enrolees of the respective commercial program. Therefore, studies evaluating outcomes of fee-paying commercial weight loss program participants can establish the nature of consumer engagement and the degree of weight loss that can be expected after specific periods of enrolment (118).

Commercial weight loss providers commonly offer web-based versions of their programs. Recent systematic reviews of web-based weight loss interventions have highlighted their potential to achieve significant weight loss (27, 33, 35). However, only one commercial web-based weight loss program (eDiets) has undergone rigorous testing within two RCTs, conducted in 2004 and 2007 (24, 25). The first RCT found the program achieved significantly less weight loss compared to a self-help manual, after 12-months (24), while the second compared eDiets to a structured behavioural web-based program and found the behavioural program achieved significantly greater weight loss compared to eDiets after 12-months (25). Therefore, further research is required to evaluate the weight change achieved from commercial web-based weight loss programs.

A 2010 systematic review of web-based weight loss interventions found that greater weight loss is likely to be associated with increased use of web-based program features (Chapter Three). This is consistent with the majority of studies investigating the association between intervention exposure and outcomes, i.e. greater use of program components within web-based interventions is associated with greater weight loss or weight loss maintenance. This includes log-ins (25, 36, 39, 43, 45, 49, 53, 59, 61), self-monitoring of weight, diet and/or exercise (24, 25, 40, 43, 47, 51, 55, 58, 59),

attendance at online meetings or chat sessions (25, 40, 51), forum posts (25, 51), viewing online lessons (58), as well as overall website use (91). Therefore, a vital component of achieving successful weight outcomes through web-based weight loss interventions appears to be their ability to engage participants. However, we have limited knowledge of whether the association between website use and weight loss holds true for fee-paying members of commercial web-based programs.

Therefore, the primary aim of this study was to describe the weight loss achieved by a cohort of enrolees of a commercial web-based weight loss program, among participants who subscribed to the program for 12- or 52-weeks. The secondary aim was to describe participants' use of the web-based program, overall and by percentage weight loss category and determine if website use differed by percentage weight loss category.

5.2 Methods

5.2.1 Participants and design

Participants were eligible for inclusion in the study if they paid for a subscription to the program from August 15th 2007 to May 31st 2008. To join the program, participants must have been 18 to 75 years of age and had a BMI ≥22 kg/m^2, based on self-reported height and weight. When participants enrolled they purchased a subscription plan of 4-, 12-, 16- or 52-weeks duration. In 2007/08 a subscription cost $AU16.50 to $AU79.95 per month, and was dependant on the number of months a participant subscribed. Participants could not unsubscribe from their selected plan until the subscription timeframe had elapsed, unless they had special circumstances that prevented them from completing their subscription (e.g. pregnancy, financial difficulties).This study included participants who subscribed for the most popular durations of 12- or 52-weeks. Data related to free or non-consecutive subscriptions (≥7 days apart) were also excluded.

Characteristics of the full cohort (Chapter Four) and the sub-group who subscribed for periods of 12- and 52-weeks (Chapter Six) have been previously published.

5.2.2 The commercial web-based weight loss program

In 2007/2008 SP Health Co. Pty Ltd. (SP Health Co.) offered a web-based weight loss platform that was commercially available in Australia as The Biggest Loser Club (www.biggestloserclub.com.au). It was promoted as a 12-week program, but participants could choose to subscribe for longer to assist with further weight loss

and/or maintenance. The self-directed program incorporated evidence-based weight management strategies and aligned with key elements of social cognitive theory (148). Participants set a goal weight, and were recommended to work towards this target in “mini goals” (e.g. 5kg or 5%). Participants were encouraged to self-monitor by reporting their weight or other body measurements via the website or SMS, and could view graphs and charts detailing their progress over time (e.g. weight and waist circumference change). Participants were encouraged to weigh-in once per week and received weekly reminders to do so via email or SMS during the initial 12-week program. A daily EI target was set based on the participant’s sex, weight, height and physical activity level, to facilitate either a weight loss of 0.5 to1 kg per week or maintain current weight. Participants were encouraged to self-monitor their dietary intake and exercise using an online diary, which calculated daily EI and expenditure. Online information in the form of weekly tutorials, fact sheets, meal and exercise plans and weekly challenges was provided during the initial 12-week program. After 12-weeks, participants continued to receive weekly web-based tutorials. Participants were also prompted to access the online information via a weekly email. Social support was available via a discussion board to communicate with other members.

5.2.3 Data collection

All data were collected by SP Health Co. and provided to the researcher in de-identified form and included: enrolment survey responses (anthropometrics [weight and height] and demographics [age, gender, and postcode]), subscription data (date of enrolment, date membership ceased and subscription plans held), website use (date of log-in, online food and exercise diary entries and posts to the discussion forum) and self-reported weight records (date of record and weight recorded). Ethics approval for the study was obtained from the University of Newcastle Human Research Ethics Committee.

5.2.4 Measures

Participants’ characteristics were captured from the enrolment survey with self-reported height and weight used to calculate BMI [weight (kg)/height $(m)^2$], which was categorized as healthy, overweight or obese using the WHOs BMI classification (7). Reported postcodes were assigned an IRSAD tertile (ranked from 1=disadvantage to 10=advantaged) (141), as an indicator of socio-economic status, as well as an ARIA (142) to classify residential level of remoteness.

Data related to the subscription plans participants held were used to determine whether participants enrolled for 12- or 52-weeks. The date of enrolment and date membership

ceased were used to calculate the number of days each participant was a member of the program, and therefore how many participants cancelled their subscription. The self-reported weight records were used to describe the number of people who weighed-in each week. The self-reported weights (kg) were used to determine the weight change achieved. The total number of days per week each of the website features (log-ins, food diary entries, exercise diary entries and forum posts) were used was calculated to describe overall website use.

5.2.5 Data analysis

Data analysis was undertaken using Stata 11.0 (StataCorp, College Station, Texas, USA), with *p* values less than 0.01 considered statistically significant. Descriptive statistics are described as means (SD) for normally distributed continuous variables, medians (Interquartile range [IQR]) for non-normal continuous data and percentages for categorical variables.

Absolute and percentage weight change were calculated from enrolment to 12-weeks for participants who subscribed for 12-weeks and from enrolment to 52-weeks for participants who subscribed for 52-weeks. The primary analysis, to determine the weight change achieved by all program enrolees, was conducted using Generalised Linear Mixed Models (GLMM) containing available self-reported weight records for all participants. GLMM was used, as this is the preferred method for longitudinal data with missing values (149, 150). Baseline age, BMI, socio-economic status and remoteness were controlled for in the analyses as potential confounders.

A secondary sensitivity analysis was conducted to determine the robustness of the results from the GLMM approach. This analysis was required as GLMM are based on the assumption that missing data are missing-at-random, which many not be the case for data reported as part of a weight loss program. Therefore a sensitivity analysis was conducted by imputing missing data for weight using the last observation carried forward (LOCF) method.

Spearman's rank correlations were calculated to explore associations of weight change with website use. This included the percentage weight change results from the LOCF analyses. Participants were divided into four percentage weight loss categories (Weight gain, 0 to <5%, 5 to <10% and ≥10% weight loss) based on the LOCF analysis results. The median (IQR) website use was described by percentage weight loss group, and differences between groups investigated using Kruskal-Wallis Test for Equality of Populations.

5.3 Results

5.3.1 Participant characteristics

Participant flow is reported in Figure 5.1. A total of 11341 participants subscribed to the program between August 15th 2007 and May 31st 2008. This study included 9599 participants, of which 6943 subscribed to the program for 12-weeks, and 2656 for 52-weeks. Participant characteristics at enrolment have been described in detail elsewhere (Chapter Four). In summary, participants had a mean (SD) age of 35.7 (9.5) years, and were predominantly female (86%), obese (61%), of moderate-to-high socioeconomic status (85%) scored between 5 and 10 on IRSAD), and from major cities in Australia (75%). Participants who subscribed for 12-weeks were significantly younger (35.3 vs. 36.7 years), had lower BMI (31.8 vs. 35.8), were of higher socioeconomic status (39.1 vs. 32.8% IRSAD 9-10), and were more likely to live in major cities of Australia (76.4 vs. 72.7%), compared to 52-weeks subscribers. Three percent (n=238) of 12-week and 23% (n=605) of 52-week subscribers cancelled their subscription during their subscription period due to special circumstances.

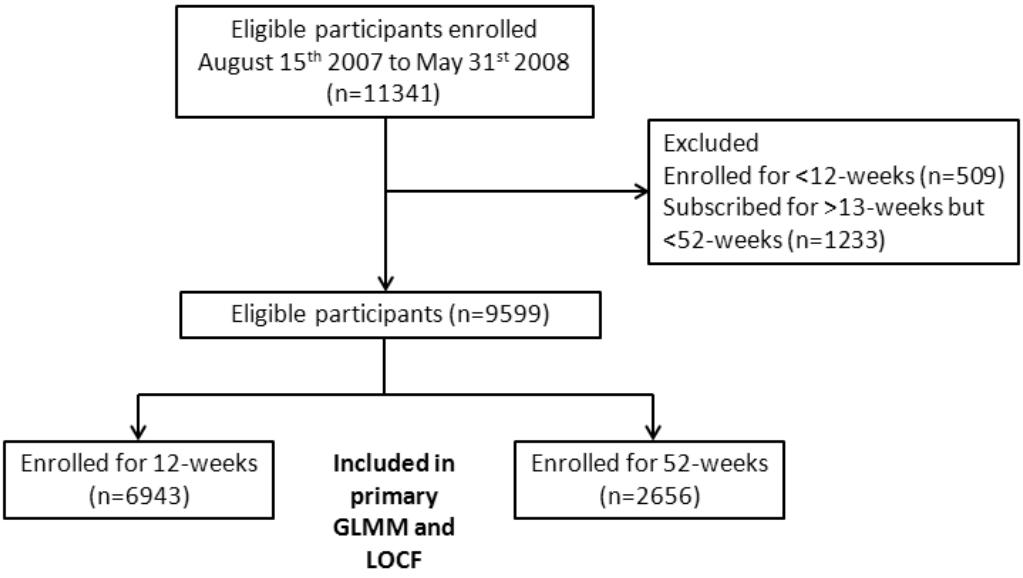


Figure 5.1 Participant flow

5.3.2 Self-reported weight record

The proportion of participants who self-reported their weight each week declined substantially over time (Figure 5.2). Therefore, the amount of missing weight data increased. For both 12- and 52- week subscribers the highest proportion of

participants self-reported their weight during week 2 (72% and 73%). For 12-week subscribers, only 11% (n=792) self-reported their weight during their final week of the program (i.e. 89% of participants' weight data was missing). For 52-week subscribers, the decline in the number of participants self-reporting their weight was continuous from week 2 (73%) to 32 (12%). However, after week 32, the percentage of participants self-reporting a weight reached a plateau but remained steady at 9 to 11%, until 52-weeks. Therefore, 91% (n=2412) of participants' weight data was missing at week 52.

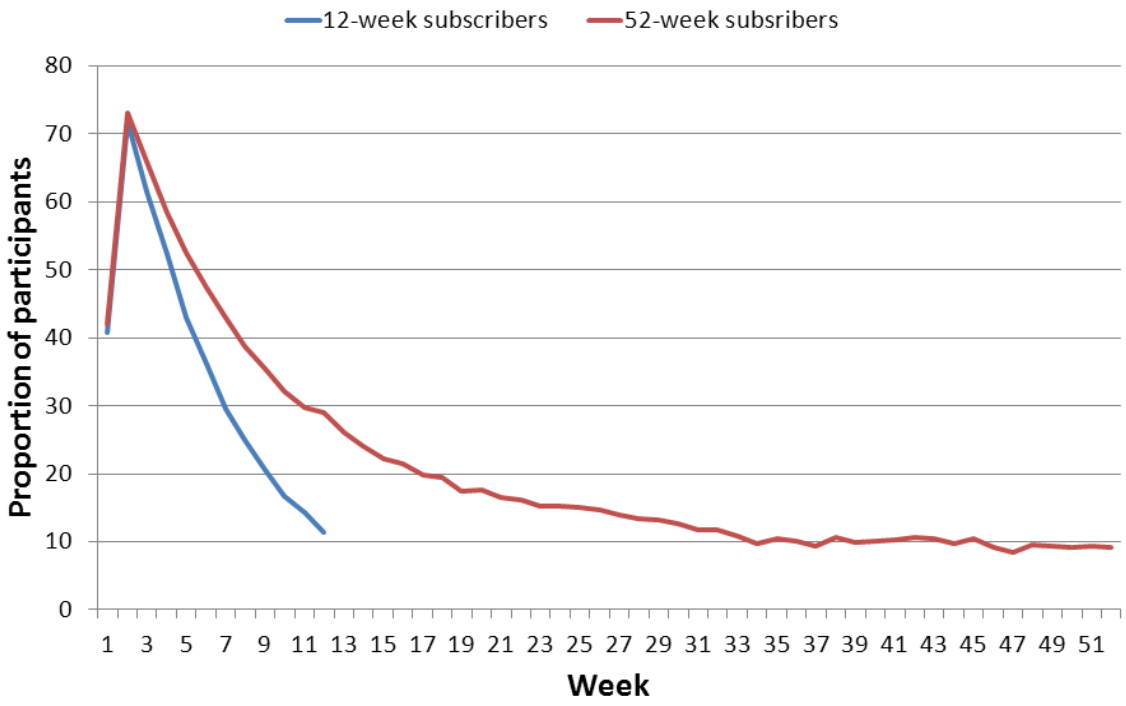


Figure 5.2 Number of participants (%) who weighed-in per week, by 12- and 52-week subscribers

5.3.3 Weight change: Primary analysis

Weight change results for 12- and 52-week subscribers are described in Table 5.1.The GLMM gave a mean self-reported weight reduction for 12-week subscribers of -5.6kg (95% CI: -5.8 to -5.5) or -6.2% and included an average of 5.2 weekly self-reported weight records per participant.

The mean self-reported weight change among 52-week subscribers was -8.4kg (95% CI: -9.0 to -7.8) or -6.9% from the GLMM. The analysis included an average of 11.8 weekly self-reported weight records per participant.

5.3.4 Weight change: Sensitivity analysis

The sensitivity analysis using LOCF gave a mean self-reported weight loss of -2.6kg (95% CI:-2.7 to -2.5) or -3.0% and 21% (n=1479) achieved ≥5% weight loss after 12-weeks (Table 5.1).The sensitivity analysis using LOCF gave a mean self-reported weight change of -3.6kg (95% CI: -3.8 to -3.3) or -3.5% from baseline to 52-weeks with 29% (n=777) of participants achieving ≥5% weight loss from enrolment to 52-weeks (Table 5.1).

Table 5.1 Mean (95% CI) weight change for a cohort of participants who subscribed to a commercial web-based weight loss program for 12- or 52 weeks

			GLMM analysis	**LOCF analysis**
12-week subscribers n=6943	Absolute weight change(kg)		-5.6 (-5.8 to -5.5)	-2.6 (-2.7 to -2.5)
	Percentage weight change (%)		-6.2 (-6.3 to -6.1)	-3.0 (-3.0 to -2.9)
	Percentage weight change category (% of participants)	Weight gain		6.1%
		0 to <5%		72.6%
		5 to <10%		17.4%
		10% or more		3.9%
52-week subscribers n=2656	Absolute weight change (kg)		-8.4 (-9.0 to -7.8)	-3.6 (-3.8 to -3.3)
	Percentage weight change (%)		-6.9 (-7.3 to -6.5)	-3.5 (-3.8 to -3.3)
	Percentage weight change category (% of participants)	Weight gain		16.0%
		0 to <5%		54.8%
		5 to <10%		17.9%
		10% or more		11.4%

Difference from baseline to 12- and 52-weeks statistically significant for all analyses (p<0.001)

5.3.5 Website use

Website use for 12- and 52-week subscribers is presented in Table 5.2. To summarize, 12-week subscribers logged-on to the website a median of 13 days. They made food entries to the web-based diary a median of 7 days, and exercise entries 3 days. The median number of days 12-week subscribers posted to the discussion forum was zero. Among 52-week subscribers the median number of days participants logged-on was 21 days. They used the web-based diary for food entries a median of 8 days and exercise entries a median 3 days, with a median of zero posts to the discussion forums.

5.3.6 Website use and weight change

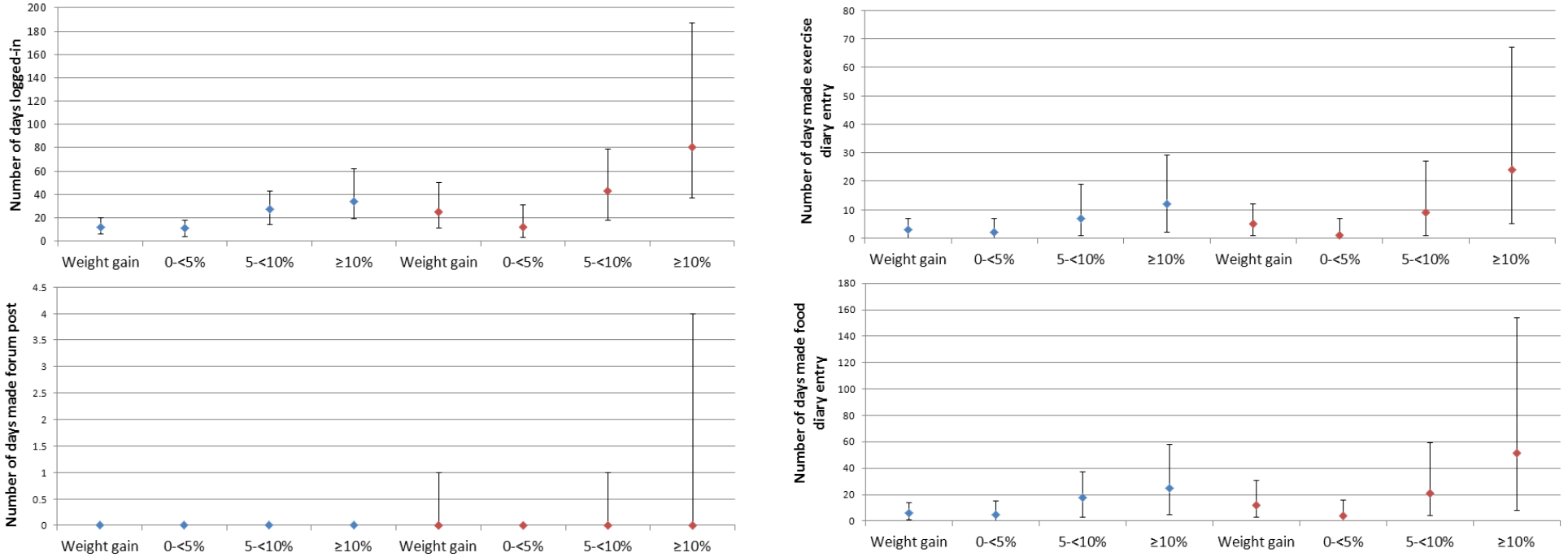
For both 12- and 52-week subscribers, percentage weight change was significantly positively correlated (p<.001) with the number of days each website feature was used (Table 5.3). The strongest correlations were found between the number of days participants logged-on and weight change, for 12- and 52-week subscribers. The weakest correlations were found between forum posts and weight change, in both subscription groups. The strongest correlations were in the 12-week subscription group, for all website features, except forum posts where the correlation between forum posts and weight change was stronger among 52-week subscribers.

Table 5.2 Spearman correlations between website use and percentage weight change (kg) among 12- and 52-week subscribers.

	12 weeks (n=6943) r[a]	52 weeks (n=2656) r[a]
Log-ins	-0.55	-0.43
Food diary entries	-0.39	-0.33
Exercise diary entries	-0.38	-0.33
Forum posts	-0.12	-0.18

[a]All statistically significant (p<0.001)

The median number of days participants used each website feature increased significantly (p<0.001) by category of higher percentage weight loss (Figure 5.3), for both 12- and 52-week subscribers. Twelve-week subscribers who lost 10% or more of their enrolment weight logged-on a median of 34 days, made food entries to the web-based diary 25 days and exercise entries 12 days, whereas those who gained weight logged-on a median of 12 days, made food entries to the web-based diary 6 days and exercise entries 3 days. For 52-weeks subscribers, those who lost 10% or more of enrolment weight logged on a median of 81 days, made food entries to the web-based diary 52 days, and exercise entries 24 days, compared to those who gained weight, who had a median of 25 login days, used the web-based food diary for food entries a median of 12 days, and exercise entries for 5 days.



Percentage weight change categories shown as median (diamond) with first and third quartiles, for 12-week subscribers (blue) and 52-week subscribers (red). Percentage weight change categories show percentage weight change from initial weight from LOCF analysis: Weight gain (12-week n=423, 52-week n=424), 0 to <5% weight loss (12-week n=5041, 52-week n=1455), 5 to <10% weight loss (12-week n=1206, 52-week n=475), ≥10% weight loss (12-week n=273, 52-week n=302).

Figure 5.3 Median days each website feature was used by 12- and 52-week subscribers, by categories of percentage weight change

5.4 Discussion

The primary aim of this paper was to describe the weight loss achieved by a large cohort of participants who subscribed to a commercial web-based weight loss program for either 12- or 52-weeks. The study addresses an existing gap in the literature [5, 6], by reporting weight loss outcomes in a large, naturalistic cohort of commercial users of a web-based weight loss program and its association with website feature usage. This study is one of only a small number of evaluations of commercial weight loss program cohorts and only the second to employ a robust statistical analysis, as opposed to reporting results for program completers only. To the authors' knowledge, it is the first cohort study reporting outcomes from a large group of enrolees in a commercial web-based program.

5.4.1 Weight loss

Our primary analysis using GLMM indicate that both 12- and 52-week subscribers, achieved statistically significant weight loss. Mean weight loss also exceeded the benchmark (≥5%) for clinically important weight loss and improvement in weight-related morbidity, particularly incidence of type 2 diabetes mellitus (6, 14). Furthermore, 21% of 12-weeks and 29% of 52-week subscribers achieved a weight loss ≥5%, based on the results from the LOCF analysis.

However, the sensitivity analysis at both time points demonstrated less weight loss compared to the GLMM. GLMM assume that any data missing from the model follow the same trajectory as the included data (in this case weekly weight change). As the average number of weekly weight records included is low and most people self-reported their weekly weight within the initial weeks of the program only, the GLMM results may be biased towards those who self-reported more weekly weights. It is likely that the participants who did not enter their weights were the less successful participants. This is supported by our previous findings that participants with poor eating and activity habits were more likely to stop using the program (Chapter Six). Furthermore, it is also likely that the rate of weight loss during the initial weeks of the program was higher compared to the later stages of the program; therefore the trajectory of the GLMM may also be biased towards higher self-reported weight loss. Therefore, the true weight loss achieved by all participants at each time-point is likely to be somewhere in the range between the GLMM and LOCF results (i.e. 12 weeks: -3.0 to -6.2%, 52 weeks: -3.5 to -6.9%). Therefore, further research is required to confirm or refute these findings prospectively and objectively in a clinical research trial.

Results from the only two RCTs conducted using another commercial web-based weight loss program (eDiets) reported a mean percentage weight change of -2.8% (25) and -1.1% (24) after 12-months. Both eDiets and the commercial web-based program evaluated in this study included many of the components that have been suggested as key elements of successful web-based weight management programs (30, 31), such as self-monitoring, feedback and social support. However, eDiets also included additional features not available in the program evaluated in the current study, such as on-line meetings, peer-mentoring (24, 25) and face-to-face sessions with a psychologist (24) . It was expected that these additional program components would lead to greater weight change. However, the mean weight change achieved in the current study was greater. This is potentially due to the increased capabilities of the Internet since the first study was conducted and/or differences in study design. So, although both programs provided similar features, those in the current study may potentially have been more engaging, easier and/or faster for participants to use, reducing the burden to adhere.

5.4.2 Website use and weight loss

The second aim of the paper was to describe participants' use of the web-based program and its features and determine if website use was associated with degree of weight loss.

The study demonstrated a significant positive correlation between the number of times each website feature was used and weight change. Therefore, the results support previous research (Chapter Three) suggesting that ongoing engagement with web-based weight loss programs may enhance weight loss in the long-term. Given this association, strategies are required to encourage participants to use web-based weight loss programs consistently, to ensure the majority of participants are given the opportunity to achieve clinically important weight loss.

However, at the group level, the average use of the commercial web-based weight management program features appears to be low and inconsistent. The majority of subscribers log-in and try the web-based diary at least once, however engagement decreases quite fast. This is demonstrated by the initial decline in weekly self-reported weight records overtime for both 12- and 52-week subscribers, and is consistent with other public health interventions delivered via the Internet, where usage declines after the initial weeks of the intervention (151).

As this commercial web-based weight loss program is self-directed, the intensity or frequency of website use is not prescribed. Therefore this study provides valuable data and insight into what level of website use may be feasible, and more importantly, what

level is required to be effective in achieving weight change in a commercial setting. Interestingly, participants who achieved significant weight loss did not use the website unrealistically or excessively. For example, those who achieve ≥ 10% weight loss from baseline to 12-weeks logged-in approximately 40% of the possible days (34 days out of 84) and used the web-based diary 30% of possible days (25 days out of 84). These findings suggest that developing program targets for weekly or monthly website use, and for specific program features, may increase usage and enhance weight loss, thus facilitating achievement of participants' weight loss goals. However, to identify optimal exposure to the website overall, as well as individual website features, further investigation of the differences in use at different stages of the program, and its association with weight loss is required. For example, this study demonstrates that participants who achieved ≥10% weight loss from baseline to 12-weeks logged-in approximately 40% of the possible days (34 days out of 84) whereas those who achieved the same percentage weight change from baseline to 52-weeks logged-in approximately 22% of the days (n=81). Therefore, further research is needed to investigate the relationship between patterns of website use overtime and the weight loss achieved at different time-points.

5.4.3 Limitations

There are several important considerations when interpreting the weight change results. Firstly, they rely on self-report, and weight is commonly under-reported [40]. However, self-reported weight recorded by participants of a web-based weight loss program has been found to be accurate compared to measured weight [41]. Secondly, a notable number of weekly weight records were missing, as the weight data is entered voluntarily by participants as part of their program participation. To address this, statistical analyses were conducted using GLMM. GLMM are one of the most robust statistical methods available as they are less influenced by the bias introduced from missing data. Additionally, a large number of individual weekly weight records were included in each analysis (31228 and 36339) allowing the analyses to be strongly powered. Therefore, the results from the statistical analysis provide us with an indication of the weight loss achieved by a cohort of enrolees of a commercial web-based weight loss program. However, due to the low level of website use, and therefore the very small number of participants still self-reporting their weight at the end of their subscription period, further research is required to confirm or refute these findings, and to identify ways to increase participant engagement with the program

The website use data and the reported associations with weight change also have some limitations for noting. Firstly, the study did not consider use of all website

features, as these data were not available at the time of the study. Additional data concerning the use of all features (e.g. weekly tutorials), as well as more detailed data on the reported features (e.g. whether participants read the forum posts) would help to better understand participants engagement with the website, and the relationship between weight loss and website use. Secondly, the analysis to determine if greater website use was associated with enhanced weight loss relied on the results of the LOCF analysis. As previously stated, the true weight loss achieved by all participants is likely to be somewhere in the range between the GLMM and LOCF results. Thirdly, although an association between website use and weight loss was demonstrated, they are a large number of other factors that may have influenced participants' website use and/or weight loss (e.g. self motivation, intention to change, other weight loss strategies), that were not evaluated in this study. Therefore, the association between website use and weight loss must also be confirmed prospectively in an objective manner.

5.4.4 Conclusion

In summary, this research provides important data on an under-evaluated weight loss program medium in a large number of commercial program users. The weight loss achieved by 12- and 52- week subscribers of a commercial web-based weight loss program is likely to be in the range of the primary and sensitivity analysis results. This suggests that on average clinically important weight loss may be achieved. The findings support the need for further research to evaluate the efficacy of web-based weight loss programs and to assist in the development of strategies to increase participants' ongoing use of web-based program features.

Chapter Six: Drop-out, non-usage attrition and pre-treatment predictors of non-usage attrition in a commercial web-based weight loss program.

This paper was published in 2010.

Neve MJ, Collins CE, Morgan PJ. Drop-out, non-usage attrition, and pre-treatment predictors of non-usage attrition in a commercial web-based weight loss program. *Journal of Medical Internet Research* 12 (4): e69.

The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 8).

6.1 Introduction

Public health interventions delivered via the Internet are becoming increasingly popular, and evidence to support their ability to achieve health-related behaviour change and positive health outcomes is growing (32). However, there is a need for Internet-delivered health and lifestyle interventions to minimise attrition and boost utilisation rates in order to improve effectiveness (88, 89, 152). A recent systematic review of web-based weight loss interventions found that these interventions have the potential to achieve significant weight loss; however, they can also suffer from high drop-out and poor utilisation (Chapter 3).

Retention rates published to date for web-based weight loss programs range from 20% to 100%, with the majority less than 80% (Chapter 3). There may be an association between increased numbers of tasks prescribed or degree of participation required in web-based interventions with lower retention rates. For example, studies comparing participants in web-based weight loss interventions with control groups almost universally report higher retention among the control groups (24, 37, 48, 49, 51, 55, 135). Furthermore, in some studies, where web-based weight loss interventions are compared with web-based interventions with a greater number of features, higher retentions rates are often found in the web-based interventions with fewer features (25, 39, 43, 94).

The majority of web-based weight loss interventions report low website usage and experience a steady drop in usage over time (53). Many participants also do not achieve the level of use prescribed by the program (28, 88, 110, 151). It appears, however, that the addition of evidence-based components to web-based interventions such as behavioural therapy, human counselling, or motivational interviewing may result in greater website use compared with web-based interventions that provide basic education or information only (25, 36, 39, 43). For example, studies have demonstrated significantly higher numbers of log-ins (25, 36, 39, 43) as well as more self-monitoring occasions and higher attendance in online meetings (25) with the addition of these evidence-based components. Recent systematic reviews of web-based weight loss interventions have also acknowledged the inverse relationship between website use and weight loss (89, 110). Therefore, the ability of web-based interventions to maximise utilisation and retain participants is a crucial component of efforts to enhance effectiveness.

As participants can potentially fail to drop out of web-based interventions but stop using the website, Eysenbach (89) has suggested that exploration of attrition rates should

include drop-out attrition rates (i.e. participants who do not complete the study/program) and non-usage attrition rates (i.e. participants who stop using the website). Such knowledge is required to improve our understanding of how participants use web-based programs. Eysenbach (89) has also highlighted the importance of exploring predictors of attrition in web-based programs. Previous research has investigated pre-treatment predictors of drop-out attrition from weight loss interventions and demonstrated key socio-demographic characteristics (education level (66), employment status (66, 99), age (100, 101), gender (98)) and behavioural factors (number of previous weight loss attempts (66, 82, 102), dietary intake (82), emotional status (102, 153), binge eating (153), and weight loss expectations (82)) that were predictive of drop-out attrition. However, no consistent patterns of pre-treatment predictors of non-usage attrition from web-based weight loss interventions have been identified to date. Potential predictors include gender (94, 96), age (94-96), motivation (94), BMI (95), physical activity (95), and fruit and vegetable consumption (95).

To date, studies investigating web-based weight loss programs have predominantly been RCTs. However, RCTs could potentially overestimate or underestimate participant attrition and website use due to the inherent characteristics of volunteers and study rigor (e.g. motivated participants, additional assessment sessions, subject retention strategies, greater accountability, and contact with study staff). Therefore, RCTs may not represent attrition or website usage in the 'real world'. Studies that follow real-world participants of web-based weight loss programs are, therefore, needed to ascertain true drop-out and non-usage attrition rates in order to enhance program effectiveness.

Therefore, the first aim of this study was to describe in a large cohort of real-world users of a commercial web-based weight loss program, the prevalence of drop-out and non-usage attrition. The second aim was to determine which pre-treatment socio-demographic and behavioural characteristics predict non-usage attrition.

6.2 Methods

6.2.1 Participants and design

Participants were adults 18 to 75 years of age who enrolled in a commercial web-based weight loss program from August 15th 2007 to May 31st 2008, and paid a subscription to access the program. A self-reported BMI of ≥22 kg/m^2 was required to enrol in the program. Only participants who subscribed for 12- or 52-weeks were included in this study, as they are the most predominant subscription lengths.

Participants who did not pay for their initial subscription (e.g. free promotional program trials) were excluded. Data related to free or non-consecutive memberships (≥7 days apart) were also not included in the analysis. Membership status and website use were tracked for the duration of the subscription.

6.2.2 The commercial web-based weight loss program

SP Health Co. developed the web-based weight loss platform that is commercially available as The Biggest Loser Club. In summary, the online program incorporates key evidence-based weight management strategies and aligns with key elements of social cognitive theory (148) including self-management, social support, self-efficacy, outcome expectations and expectancies, and perceived barriers/facilitators. The key features of the program include goal setting (goal weight, daily calorie goal, and weekly exercise goals), self-monitoring of weight via weekly weigh-ins, as well as food and exercise using an online diary, educational material provided by weekly email, and an online discussion forum. Participants who enrol in the program purchase a specific subscription plan. The subscription plans are of 4-, 12-, 16-, or 52-weeks duration and are paid for either prospectively at enrolment or by monthly instalments. In 2007/2008 the cost of the program ranged from $AU16.50 to $AU79.95 per month. The cost per month to the participant was lower if they subscribed for longer and/or paid up front. Participants were predominantly recruited via marketing of the program through a reality television program, The Biggest Loser, Australia.

6.2.3 Data collection

The proprietors of program, SP Health Co, store all data entered by participants accessing the program website. Data stored include responses to an enrolment survey (Appendix 2), subscription plans held, and use of a number of the website features (log-ins, online food and activity diary entries, weigh-ins, and posts to the discussion forum). SP Health Co. extracted stored data in de-identifiable form for up to 52-weeks from enrolment for all participants who met the inclusion criteria. Ethics approval for the study was obtained from the University of Newcastle Human Research Ethics Committee.

6.2.4 Pre-treatment characteristics

Participants' pre-treatment characteristics were captured from the enrolment survey. Participants' self-reported height and weight were used to calculate BMI (weight (kg)/height $(m)^2$) which was categorised as healthy, overweight, or obese using the WHO BMI classification (7). Reported postcodes were assigned an IRSAD decile

(ranked from 1=disadvantaged to 10=advantaged) as an indicator of socioeconomic status (141). The remoteness of the area in which participants lived was classified according to the ARIA of their postcode (142). Participants' reasons for wanting to achieve weight loss were grouped as health-related reasons (e.g. doctor recommended or health scare) and reasons not related to health (e.g. to look good or to enhance one's love life), and participants were categorised as having one or more health-related reasons or no health-related reasons for wanting to lose weight. Participants also selected their reasons for eating (to ease emotional upset, for the joy of it, to reduce stress, and out of boredom), whether they had eating habits associated with weight gain (frying foods, using butter in cooking, drinking full sugar soft drinks, skipping meals, drinking tea or coffee with sugar, not eating breakfast, not using low fat products, keeping snack foods in the house, and not drinking 6 or more glasses of water a day) and the number of days they exercised per week. Age and gender were also captured from the enrolment survey.

6.2.5 Website use

Website use was assessed by summing available usage data. Participants were classified as having used the website on any given day if they logged in, made an entry in the diary, posted to the forum, and/or weighed in. The total number of days per 4-week period each participant 'used' the website was calculated and categorised as 0 days, 1 to 3 days, 4 to 7 days, 8 to 15 days and 16 or more days. All website use variables were calculated from enrolment to 12- and 52-weeks for the 12- and 52-week subscribers respectively.

6.2.6 Drop-out attrition

The date a participant enrolled in the program and the date membership ceased were used to calculate the number of days each participant was a member of the program (i.e. duration of membership). The date membership ceased was the end date of the participant's subscription plan unless there were special circumstances that prevented the participant from completing the subscription (e.g. pregnancy or financial constraints). Participants were classified as members of the program at 12- or 52-weeks if they held an active subscription plan at that point in time (≥ 78 days for 12-week subscriptions and ≥ 359 days for 52-week subscriptions). Otherwise, they were classified as a drop-out.

6.2.7 Non-usage attrition

Non-usage attrition was only considered for participants who completed their subscription (i.e. they did not drop out). Participants were classified as a nonuser at 12- or 52- weeks if they stopped using the website features (i.e. no log-ins, food/activity diary entries, weigh-ins, or posts to the discussion forum). The week a participant was classified as a 'nonuser' was the week he or she ceased using the website and did not return.

6.2.8 Data analysis

Data analysis was undertaken using Stata 11 IC (StataCorp LP, College Station, USA). Participant pre-treatment characteristics were described as means (SD) for continuous variables and percentage for categorical variables. Subscription length (12- and 52-weeks) group differences were tested using independent t tests for continuous variables and chi-square tests for categorical variables. Participants' pre-treatment characteristics were investigated as predictors of non-usage attrition for 12- and 52-week subscribers using Cox proportional hazards regression analyses. The time variable was the duration of usage (in weeks), and non-usage was considered a failure. Univariate analyses were conducted on all pre-treatment predictor variables of interest and those with $p<0.2$ were included in a stepwise regression analysis to find the most parsimonious model. The proportional hazards assumption was tested for each model using the Schoenfeld residuals. The significance level was set at $\alpha=0.05$.

6.3 Results

6.3.1 Pre-treatment characteristics and website use

Of the 11341 participants who enrolled in the commercial Web-based weight loss program between August 15th 2007 and May 31st 2008, 9599 were eligible for inclusion in the study, and 1742 were excluded (Figure 6.1). In all, 72% (n=6943) of eligible participants subscribed to the program for 12-weeks, and 2656 subscribed for 52-weeks.

The characteristics of the eligible participants are outlined in Table 6.1. In summary, 31% (n=2975) of participants were overweight, 61% (n=5866) were obese, and 86% (n=8279) were female. The mean (SD) age of participants was 35.7 (9.5) years, 85% (n=8022) of participants were of moderate-to-high socioeconomic status (i.e., scored between 5 and 10 on IRSAD), and 75% (n=7125) were from major cities in Australia. The majority of the group reported some healthy eating habits such as eating breakfast

(74%, n=7052) and using low fat products (65%, n=6269), but many (53%, n=5098) also reported poor eating habits such as skipping meals. Most participants reported inadequate levels of physical activity at enrolment, with 51% (n=4875) exercising less than 2 days per week.

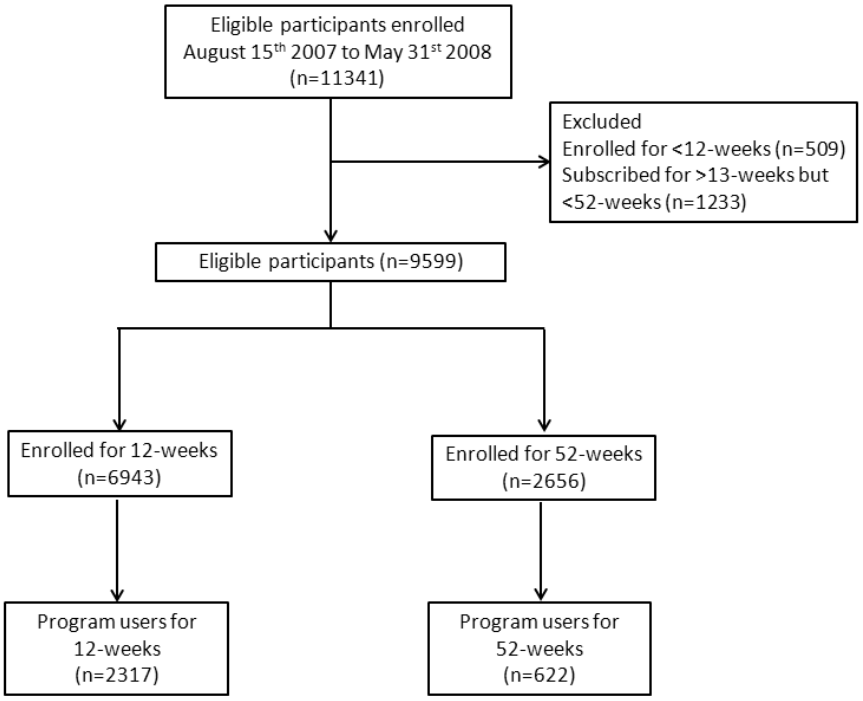


Figure 6.1 Participant flow

Statistically significant differences in pre-treatment characteristics of 12- and 52-week subscribers were evident, with the mean (SD) age of participants who subscribed for 52-weeks being significantly greater (35.8 [7.1] years vs. 31.8 [6.1] years), having a higher mean (SD) BMI (36.7 [9.6] vs. 35.3 [9.4]), being of lower socioeconomic status (82% vs. 86% with an ISRAD of 5 to 10), and a lower proportion residing in major cities of Australia (73% vs. 76%) when compared with 12-week subscribers. A significantly higher proportion of 52-week subscribers reported poor eating habits (e.g. frying foods or drinking full sugar soft drinks), exercising less than 2 days per week, eating for emotional reasons or for the joy of it, and having health-related reasons for wanting to lose weight.

Figure 6.2 and Figure 6.3 describe overall website use. For both 12- and 52-week subscribers, the highest proportion of participants used the website on 16 days or more during weeks 1 to 4 of the program. During weeks 5 to 8 and weeks 9 to 12, the

highest proportion of 12-week subscribers did not use the website. However, of the participants who did use the website, most used it 1 to 3 days during each 4-week period. For 52-week subscribers, the highest proportion of participants used the program on 1 to 3 days from weeks 5 to 8. After this time (i.e. weeks 9 to 52) the highest proportion of participants never used the website, and the second highest proportion used the website 1 to 3 days in each 4-week period.

Table 6.1 Pre-treatment characteristics

Descriptor	Total n=9599	12-weeks n=6943	52-weeks n = 2656	*P* Value
Age (years)				
Mean (SD)	35.7 (9.5)	35.3 (9.4)	36.7 (9.6)	< .001
18 to 25 years (%)	12.8	13.5	10.8	< .001
25 to 35 years (%)	37.4	38.6	34.5	
35 to 45 years (%)	33.2	32.3	35.6	
45 to 55 years (%)	13.2	12.6	14.7	
55 to 65 years (%)	3.1	2.8	4.0	
65 to 75 years (%)	0.4	0.4	0.4	
Gender				
Female (%)	86.3	86.5	85.7	.30
BMI (kg/m^2)				
Mean (SD)	32.9 (6.7)	31.8 (6.1)	35.8 (7.1)	< .001
Healthy weight (%)	7.9	9.7	3.1	< .001
Overweight (%)	31.0	35.7	18.7	
Obese (%)	61.1	54.6	78.2	
Socioeconomic status (IRSAD decile) [a]				
1-2 (%)	5.8	4.9	8.0	< .001
3-4 (%)	9.4	9.1	10.3	
5-6 (%)	18.2	17.4	20.2	
7-8 (%)	29.3	29.5	28.7	
9-10 (%)	37.4	39.1	32.8	
Remoteness (ARIA)[b]				
Major city (%)	75.4	76.4	72.7	.001
Regional (%)	23.2	22.3	25.8	
Remote (%)	1.4	1.3	1.6	
Days of planned exercise[c]				
0-1 days (%)	51.0	50.6	51.8	< .001
2 or more days (%)	49.0	49.4	48.2	
Eating habits				
Fry foods (%)	37.9	36.4	42.4	< .001
Use butter in cooking (%)	36.1	35.4	38.2	.01
Drink full sugar soft drinks (%)	29.4	28.2	32.6	< .001
Skip meals (%)	53.1	51.3	58.0	< .001
Drink tea or coffee with sugar (%)	43.7	44.4	41.9	.03
Eat breakfast (%)	73.5	74.7	70.3	< .001
Use low fat products (%)	65.3	66.3	62.7	.001
Keep snack foods in the house (%)	59.8	58.9	62.1	.004
Drink 6+ glasses of water a day (%)	40.7	41.2	39.4	.10
Reasons for eating				
To ease emotional upset (%)	56.0	55.0	58.7	.001
For the joy of it (%)	55.9	53.4	56.9	.002
To reduce stress (%)	44.6	44.0	46.1	.07
Out of boredom (%)	78.6	78.9	77.9	.26
Reasons for weight loss				
One or more health-related reasons for weight loss (%)	54.7	53.2	58.9	< .001

[a] Total n = 9455; at 12-weeks n = 6841; and at 52-weeks, n = 2614
[b] Total n = 9456; at 12-weeks, n = 6842; and at 52-weeks, n = 2614
[c] Total n = 9569; at 12-weeks, n = 6923; and at 52-weeks, n = 2646

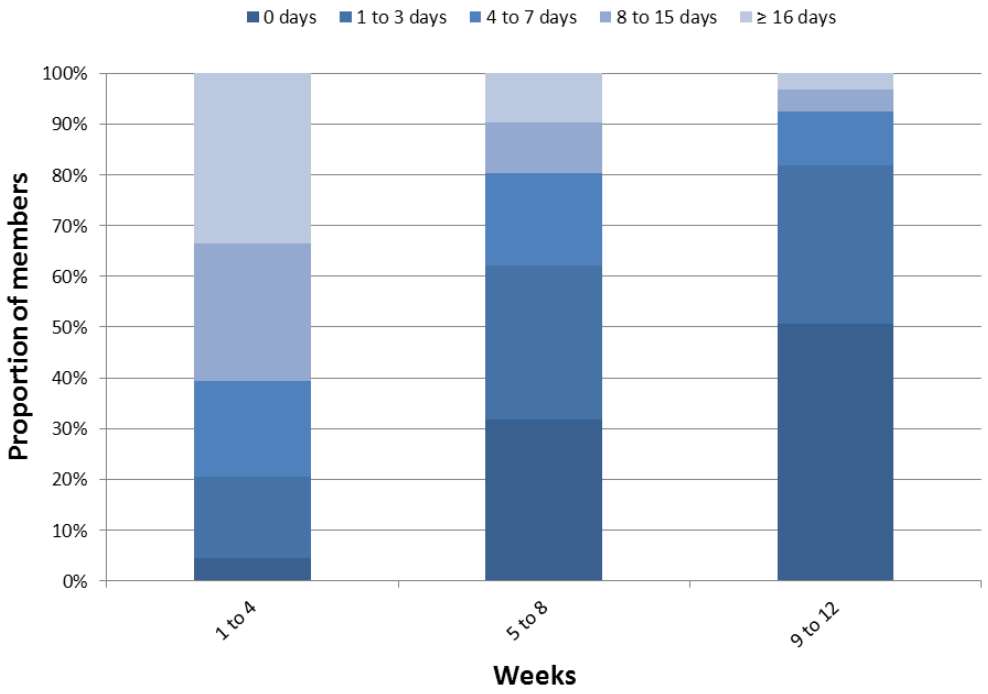


Figure 6.2 Website use from enrolment to 12-weeks among 12-week subscribers

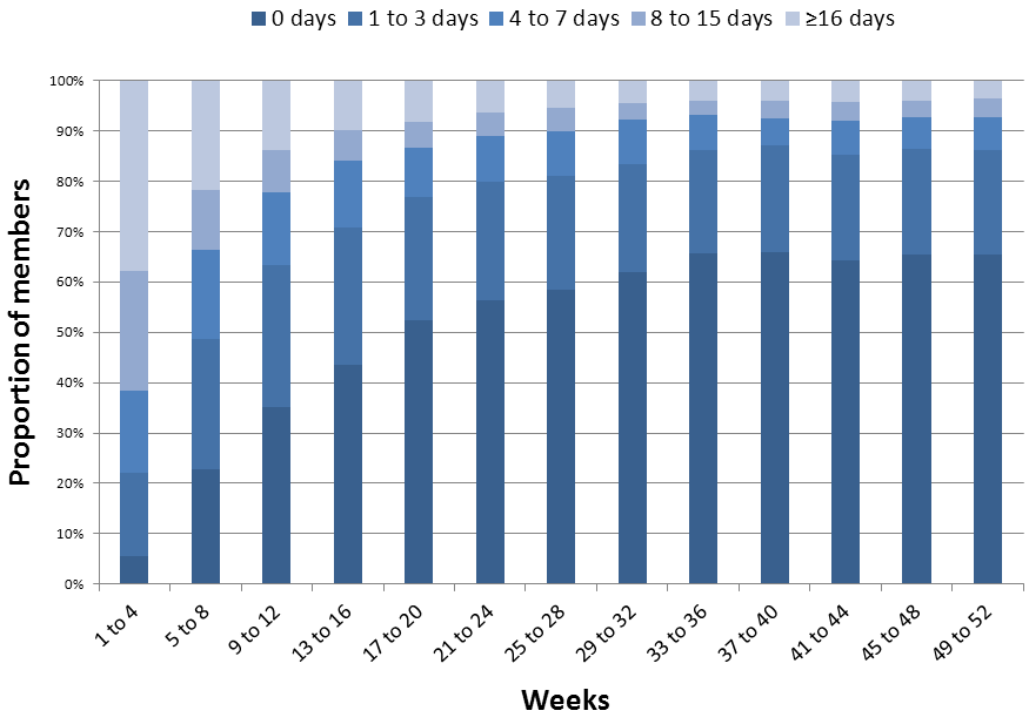


Figure 6.3 Website use from enrolment to 52-weeks among 52-week subscribers

6.3.2 Drop-out attrition

Figure 6.4 and 6.5 present drop-out attrition curves for 12- and 52-week subscribers respectively. Of the 6943 participants who subscribed to the program for 12 weeks, the retention rate was 97% at 12-weeks, with 238 participants (3%) dropping out over the 12-week period (Figure 6.4). For the 2656 participants who subscribed to the program for 52-weeks, the retention rate was 77% with 605 dropping out over the 52-week period (Figure 6.5).

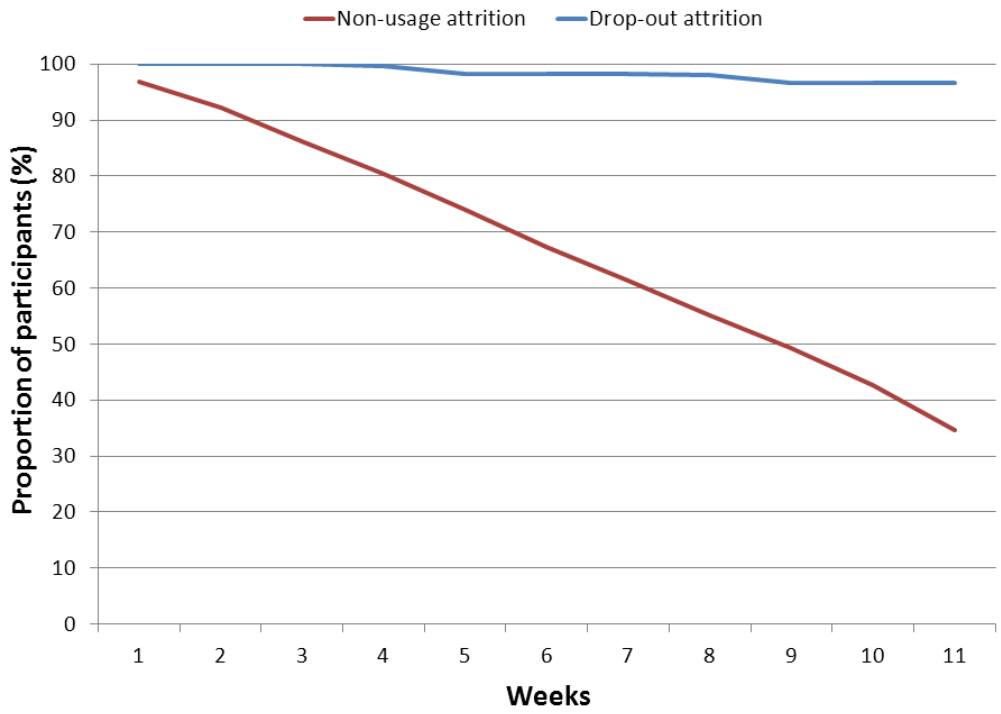


Figure 6.4 Drop-out attrition and non-usage attrition from enrolment to 12 weeks among 12-week subscribers

6.3.3 Non-usage attrition

Figure 6.4 and 6.5 present non-usage attrition curves for those who subscribed and completed a 12- or 52-week subscription, respectively. Of the 6705 participants who subscribed to and completed 12-weeks of the program, 35% (n=2317) of participants were classified as 'users' of the program at 12-weeks. The lowest proportion of participants stopped using the program during weeks 1 and 2. The proportion of participants who stopped using the program remained steady from week 3 to week 10 (6% to 7% stopped using per week) but increased during week 11 to 8%. Of the 6705 12-week subscribers, 50% (n = 3398) had become nonusers of the program by week 9 (Figure 6.4).

Of the 2051 participants who completed their 52-week subscription, 622 participants (30%) were 'users' of the program at 52-weeks. The proportion of participants who stopped using the program remained steady from week 1 to week 44 (1% to 2% stopped using per week) but increased rapidly thereafter. By week 46, greater than 50% of the 52-week subscribers were nonusers of the program (Figure 6.5).

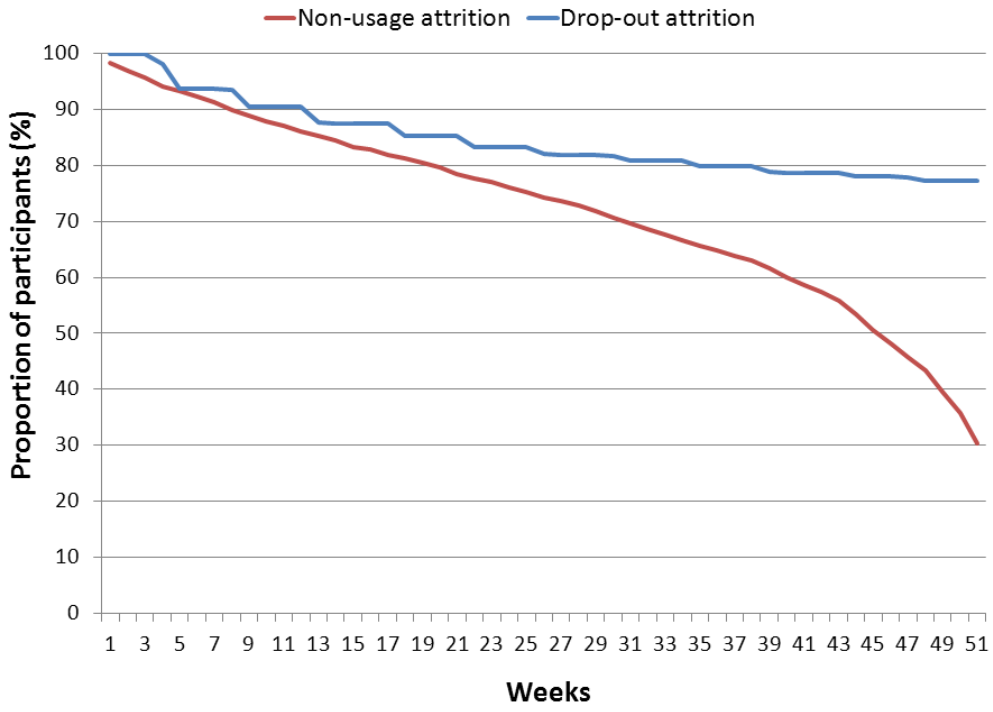


Figure 6.5 Drop-out and non-usage attrition from enrolment to 52 weeks among 52-week subscribers

6.3.4 Predictors of non-usage attrition: 12-week subscribers

Table 6.2 describes unadjusted predictors of non-usage attrition among 12-week subscribers from univariate analyses. In the multiple regression analysis (Table 6.2), skipping meals (Hazard Ratio (HR):1.12, 95% CI) 1.04 to 1.19, *p*=0 .001) and eating to ease emotional upset (HR: 1.11, 95% CI 1.04 to 1.18, *p*=0.001) were the two pre-treatment characteristics found to significantly increase a participants risk of being a nonuser. Participants who exercised more than 1 day per week were at a significantly decreased risk of being a nonuser (HR: 0.76, 95% CI 0.72 to 0.81, *p*<0 .001). Participants who ate breakfast (HR:0.88, 95% CI 0.82 to 0.95, *p* =0.001) were also at decreased risk of non-usage, as well as participants aged 45 to 65 years (HR for 45 to 55 years of age:0.83, 95% CI 0.73 to 0.93, *p*=0.001; HR for 55 to 65 years of age :0.80, 95% CI 0.66 to 0.99, *p* =0.04).

Table 6.2 Risk of non-usage attrition for 12-week subscribers

Risk Factor	Unadjusted n = 6705		Adjusted n = 6686[d]	
	Hazard Ratio (95% CI)	*p*	Hazard Ratio (95% CI)	*p*
Age (years)				
18 to 25 years	1.00 (reference)		1.00 (reference)	
25 to 35 years	0.92 (0.84 to 1.01)	0.09	0.93 (0.85 to 1.02)	0.12
35 to 45 years	0.92 (0.84 -1.01)	0.09	0.93 (0.85 to 1.03)	0.15
45 to 55 years	0.81 (0.72 to 0.91)	<0 .001	0.83 (0.73 to 0.93)	0.001
55 to 65 years	0.77 (0.63 to 0.95)	0.01	0.80 (0.66 to 0.99)	0.04
65 to 75 years	0.54 (0.29 to 1.01)	0.05	0.63 (0.34 to 1.17)	0.14
Gender				
Male	1.00 (reference)			
Female	0.85 (0.78 to 0.92)	< 0.001		
BMI (kg/m^2)				
Healthy weight	1.00 (reference)			
Overweight	1.02 (0.92 to 1.14)	0.66		
Obese	1.11 (1.00 to 1.24)	0.04		
Socioeconomic status (IRSAD decile)[a]				
1-2	1.00 (reference)			
3-4	1.04 (0.88 to 1.23)	0.67		
5-6	0.97 (0.83 to 1.13)	0.69		
7-8	1.01 (0.87 to 1.17)	0.93		
9-10	1.03 (0.89 to 1.19)	0.72		
Remoteness (ARIA)[b]				
Major city	1.00 (reference)			
Regional	0.97 (0.90 to 1.04)	0.35		
Remote	1.17 (0.91 to 1.49)	0.21		
Days of planned exercise[c]				
0 to 1 days	1.00 (reference)		1.00 (reference)	
2 or more days	0.74 (0.69 to 0.78)	<0.001	0.76 (0.72 to 0.81)	< .001
Eating habits				
Fry foods	1.07 (0.99 to 1.13)	0.07		
Use butter in cooking	1.06 (0.99 to 1.13)	0.07		
Drink full sugar soft drinks	1.16 (1.09 to 1.24)	<0.001		
Skip meals	1.23 (1.16 to 1.31)	<0.001	1.12 (1.04 to 1.19)	.001
Drink tea or coffee with sugar	0.99 (0.94 to 1.05)	0.84		
Eat breakfast	0.77 (0.72 to 0.82)	<0.001	0.88 (0.82 to 0.95)	.001
Use low fat products	0.85 (0.79 to 0.90)	<0.001		
Keep snack foods in the house	1.03 (0.97 to 1.09)	0.33		
Drink 6+ glasses of water a day	0.92 (0.86 to 0.97)	0.004		
Reasons for eating				
To ease emotional upset	1.07 (1.01 to 1.14)	0.01	1.11 (1.04 to 1.18)	.001
For the joy of it	0.99 (0.93 to 1.05)	0.63		
To reduce stress	1.10 (1.03 to 1.16)	0.002		
Out of boredom	0.98 (0.91 to 1.05)	0.59		
Reasons for weight loss				
One or more health -related reasons for weight loss	0.97 (0.92 to 1.03)	0.37		

[a] n = 6610, [b] n = 6611, [c] n = 6686 (all unadjusted), [d] Stratified by gender

6.3.5 Predictors of non-usage attrition: 52-week subscribers

Table 6.3 describes unadjusted potential predictors of non-usage attrition for 52-week subscribers using univariate analyses. In the multiple regression analysis (Table 6.3), eating breakfast (HR=0.88, 95% CI 0.79 to 0.99, *p*=0.04) was shown to be associated with reduced risk of non-usage attrition. Drinking tea or coffee with sugar was associated with increased risk of non-usage attrition among 52- week subscribers (HR = 1.23, 95% CI 1.11 to 1.37, *p*<0.001).

Table 6.3 Risk of non-usage attrition for 52-week subscribers

Risk Factor	Unadjusted n = 6705		Adjusted n = 6686[d]	
	Hazard Ratio (95% CI)	*p*	Hazard Ratio (95% CI)	*p*
Age (years)				
18 to 25 years	1.00 (reference)			
25 to 35 years	0.96 (0.79 to 1.16)	0.66		
35 to 45 years	0.93 (0.77 to 1.16)	0.45		
45 to 55 years	0.79 (0.63 to 0.97)	0.03		
55 to 65 years	0.68 (0.49 to 0.91)	0.01		
65 to 75 years	0.20 (0.02 to 1.44)	0.11		
Gender				
Male	1.00 (reference)			
Female	0.90 (0.78 to 1.04)			
BMI (kg/m^2)				
Healthy weight	1.00 (reference)			
Overweight	1.02 (0.74 to 1.42)	0.89		
Obese	1.04 (0.76 to 1.41)	0.83		
Socioeconomic status (IRSAD decile)[a]				
1-2	1.00 (reference)			
3-4	0.92 (0.71 to 1.18)	0.49		
5-6	0.82 (0.66 to 1.03)	0.08		
7-8	0.89 (0.72 to 1.10)	0.29		
9-0	0.82 (0.66 to 1.01)	0.06		
Remoteness (ARIA)[b]				
Major city	1.00 (reference)			
Regional	1.03 (0.91 to 1.16)	0.66		
Remote	1.05 (0.64 to 1.71)	0.89		
Days of planned exercise[c]				
0 to1 days	1.00 (reference)			
2 or more days	0.70 (0.63 to 0.78)	<0.001		
Eating habits				
Fry foods	1.12 (1.00 to 1.24)	0.04		
Use butter in cooking	1.16 (1.04 to 1.29)	0.007		
Drink full sugar soft drinks	1.12 (1.01 to 1.26)	0.04		
Skip meals	1.22 (1.10 to 1.36)	<0.001		
Drink tea or coffee with sugar	1.25 (1.13 to 1.39)	<0.001	1.23 (1.11 to 1.37)	<0.001
Eat breakfast	0.82 (0.73 to 0.92)	0.001	0.88 (0.79 to 0.99)	0.04
Use low fat products	0.84 (0.75 to 0.93)	0.001		
Keep snack foods in the house	1.09 (0.98 to 1.21)	0.13		
Drink 6+ glasses of water a day	0.93 (0.83 to 1.03)	0.15		
Reasons for eating				
To ease emotional upset	0.98 (0.88 to 1.08)	0.64		
For the joy of it	0.96 (0.87 to 1.07)	0.46		
To reduce stress	0.93 (0.84 to 1.03)	0.17		
Out of boredom	0.97 (0.86 to 1.10)	0.62		
Reasons for weight loss				
One or more health-related reasons for weight loss	0.90 (0.81 to 1.01)	0.06		

[a] n = 2019, [b] n = 2019, [c] n = 2043 (all unadjusted), [d] Stratified by exercise level

6.4 Discussion

This study is one of only a small number of studies (59-61, 63, 65, 93, 96) to follow a group of real-world participants of a web-based weight loss program and is the first to comprehensively evaluate the prevalence and predictors of non-usage attrition in a large cohort. The study demonstrates a high prevalence of non-usage attrition and highlights the need for evidence-based strategies to reduce attrition rates. Notably, we

found that a participant's age, as well as his or her eating and physical activity habits at enrolment could predict non-usage attrition.

The findings from this study are consistent with other studies that have demonstrated that individuals in the mid-to-older age group (45 to 65 years) are at decreased risk of non-usage (94-96). People in this age group have lower levels of Internet access (104), spend less time using the Internet and are less likely to use user-generated sites than younger age groups (104, 106). However, their access and use of the Internet is increasing rapidly (104, 106). Therefore, this suggests that web-based interventions may be well suited to the mid-to-older age groups.

The study findings suggest that people with poor eating or physical activity habits prior to enrolling in a commercial web-based weight loss program are most likely to stop using the program. This includes participants who exercised less than 2 days per week, skipped meals, did not eat breakfast, drank tea or coffee with added sugar, or identified eating to ease emotional upset. This suggests that these at-risk individuals may require alternate or additional support to remain an active participant of web-based programs, particularly in the short-term. Alternatively, it may be that the web-based program in its current form did not engage this group of participants. A research priority is, therefore, to determine whether different or extra website features can improve website usage in this group of at-risk individuals.

This study highlights the importance of investigating non-usage attrition to accurately describe attrition rates. The retention rates for the commercial web-based weight loss program of 97% after 12-weeks and 77% after 52-weeks were high in comparison with observational (59, 61, 65, 96) and experimental (Chapter 3) web-based weight loss intervention studies, as well as all types of behavioural weight loss interventions (90). However, as participants purchase a specific subscription plan and can only unsubscribe if they have special circumstances that prevent them from completing their subscription, the retention rates do not capture those participants who did not wish to continue using the program. The non-usage attrition at 12-weeks of 65% and at 52-weeks of 70% is higher than the drop-out attrition rates and demonstrates that a number of participants do not continue to use the commercial web-based weight loss program for the duration of their subscription. Use of the commercial website was consistent with other public health interventions delivered via the Internet, whereby use drops after the preliminary weeks of the intervention (151). For both 12- and 52-week subscribers the non-usage attrition was steady throughout the majority of the intervention, but non-usage attrition increased slightly towards the final weeks of the intervention. This opposes a previous hypothesis that suggests that by the final phase

of the intervention a stable user group should exist, resulting in less non-usage (89). The pattern of non-usage attrition in this study is most likely an interplay of several factors that potentially impact non-usage attrition either positively (e.g. cost of program, program features, and usability) or negatively (e.g. no prompts or personal contact, self-directed nature) (89).

To our knowledge, only two other studies have investigated non-usage attrition rates in a web-based interventions aiming to achieve weight loss (62, 96). The first, an observational study, described non-usage attrition rates for a physical activity focused web-based program (MiLife) and found that 79% of participants were still using the website after 12- weeks (62). The second study compared non-usage attrition rates among RCT and real-world participants of a web-based intervention (Active-Online) to promote physical activity over an 18-month period. Greater than 50% of trial participants became nonusers after approximately 11-months and 1-month for the real-world participants (96). This commercial web-based weight loss program's non-usage attrition rates were superior to the real-world participants of Active-Online but higher than MiLife (62, 96). However, both Active-Online and MiLife incorporated strategies that have been previously proposed as factors that influence non-usage attrition (89). One intervention was worksite based (62), which may have enhanced the networking and/or peer pressure and peer support, and, therefore, reversed the usual decline in non-usage (89). A number of 'push-factors' (89), including reminder emails and SMS were utilised (62, 96); therefore, participants may have felt obligated to continue using the web-based programs (89). The use of accelerometers by participants in one of the studies to monitor physical activity levels (62) may have improved the usability of the program and, therefore, increased usage rates (89). In comparison, the commercial web-based weight loss program is primarily a self-directed intervention. This may have negatively impacted usage rates, as it made it easier for participants to stop using the program (89). However, the participants paid a commercial rate to access the program, which has been previously suggested to positively impact usage rates (89). As the cost of the program varied and was dependant on the length of subscription and whether a participant paid up front or in instalments, the impact on non-usage may have varied. Therefore, the non-usage attrition rates reported in this study appear acceptable compared with previous studies, taking into consideration the existence of factors that may have influenced non-usage attrition.

6.4.1 Limitations

Potential limitations of this study include that only pre-treatment characteristics were considered as potential predictors of non-usage attrition. It is possible that other factors

such as satisfaction with the program, initial and ongoing weight loss, and external factors also influenced program use. However, the aim of this study was to determine whether it is possible to predict who will use the program at enrolment. Furthermore, although a large number of pre-treatment characteristics were explored as potential predictors of non-usage attrition, the study could have been improved by including a larger range of pre-treatment characteristics (e.g. motivation and stage of change), as well as through the use of validated measures to more comprehensively assess eating and physical activity behaviours. In addition, the study did not track the use of all features of the commercial web-based weight loss program (e.g. weekly tutorials and menu plans), as these data were not available at the time of the study. This may have overestimated non-usage attrition rates. Furthermore, the methodology assumes that non-usage is a negative behaviour. It has been suggested, however, that participants may consider web-based interventions differently from other treatment options (152). Participants who stop using the website may have achieved a positive outcome and, therefore, reduced the frequency with which they engage with the web-based program (96). Further research investigating participants' reasons for drop-out and non-usage attrition and the impact of drop-out and non-usage attrition on long-term weight loss is therefore required.

6.4.2 Implications

Adherence has been acknowledged as one of the main determinants of effectiveness (154); therefore, strategies are required to improve non-usage attrition rates among web-based weight loss program participants. Previous research (Chapter 3), including research with this cohort (Chapter 5), has demonstrated a significant correlation between the use of different website features (e.g. log-ins, use of discussion forums, online diary entries, and self-monitoring of weight) and weight change. Therefore, there is potential to improve weight loss achieved by participants of web-based weight loss programs by establishing effective methods to improve non-usage attrition, so that the majority of participants continue to use the website features in the long-term. As the mean weight change achieved by participants of this web-based weight loss program after 12- and 52-weeks has been found to be clinically important and statistically significant (Chapter 5), if strategies were successful in improving engagement, the public health impact could be substantial.

The findings from this study also highlight key pre-treatment socio-demographic and behavioural predictors of non-usage attrition. The findings are similar to other weight loss (66, 82, 102, 153) and web-based intervention studies (95), whereby individuals most in need of treatment are less likely to complete and/or engage with the

intervention. A number of previous web-based intervention studies have investigated web and non-web-based strategies to improve website engagement including periodic prompts, incentives, self-monitoring, management of participant expectations, improving intervention usability, provision of feedback, as well as contact with service providers (88). Given the self-directed nature of this intervention, the findings suggest clear evidence-based guidelines outlining the website use required to achieve significant outcomes may also improve non-usage attrition rates. One or a combination of these strategies could be provided to the participants who enrol in the program with the pre-treatment characteristics predictive of attrition. However, we do not know the most appropriate strategy or combination of strategies required to improve the use of web-based programs or whether the strategies required are consistent across population groups. In the future, such knowledge may be used as part of the enrolment process to ensure individuals enrol who are best suited to this approach and that they are provided with access to program features within the web-based program that meets their needs. Therefore, a research priority is the development and evaluation of strategies to improve non-usage attrition rates in web-based programs, including their impact on different population groups.

6.4.3 Conclusion

Previous research has identified optimisation of participant retention and website use as key challenges for all Web-based interventions (88, 89, 152). This study demonstrated the high prevalence non-usage attrition characteristic of web-based interventions and, therefore, highlights the need for evidence-based strategies to improve website use. Researchers should investigate the use of new or additional intervention strategies among participants with the pre-treatment demographic and behavioural characteristics that were found to independently predict non-usage attrition in this study.

Chapter Seven: Behavioural factors associated with successful weight loss 15-months post-enrolment in a commercial web-based weight loss program

This paper was submitted for consideration for publication in July 2011, and is currently under peer review by *Public Health Nutrition.*

The authors of the paper are Neve MJ, Morgan PJ, and Collins CE. The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 9).

7.1 Introduction

The worldwide prevalence of overweight and obesity among adults is increasing (146). However, the overall success of behavioural interventions to treat overweight and obesity is moderate (155). Successful behavioural weight loss interventions generally achieve the greatest percentage weight loss after 6-months of treatment (5% to 10%) (155). Weight loss is typically followed by gradual regain of lost weight (19). At 2-years post-treatment weight generally stabilises at 5% less than the pre-treatment weight (19) and after 5-years more than half of participants will have regained back to their pre-treatment weight, or greater (90). Given the current prevalence of overweight and obesity, there is a need for treatment strategies that not only promote initial weight loss, but that also facilitate long-term maintenance of lost weight.

Web-based weight loss interventions have emerged in recent years, as an alternative or adjunct to traditional treatment mediums. Recent systematic reviews highlight the potential of web-based treatments in achieving significant weight loss (27, 33, 35). However, they have also found that most studies fail to follow-up participants beyond the intervention period, so we do not know whether participants who successfully lose weight with web-based programs can maintain the lost weight.

Currently, commercial programs are the most accessible web-based weight loss programs for consumers (23). However only one has been rigorously evaluated in two RCTs (24, 25), and neither study followed-up participants beyond the intervention period. A small number of other commercial programs have evaluated long-term outcomes (112) and demonstrated weight loss results similar to other lifestyle interventions (122, 124-126). However, sampling bias is evident in all studies, demonstrated by inclusion of only those participants who successfully lost weight (122, 124, 125), or only evaluating results for women (126). Studies to date may misrepresent this medium's overall success due to study populations not being representative of all program participants. Therefore, there is a need for ongoing research to determine the long-term effectiveness of commercial and web-based weight loss programs in groups who are representative of those who enrol in such programs.

Research to date has identified several behavioural factors that are associated with long-term weight loss maintenance. These include consistent self-monitoring (e.g. of weight, eating habits and/or physical activity) (66, 69, 71, 81), a physically active lifestyle (66, 69, 71, 77), having healthy eating habits such as consuming less dietary fat, eating breakfast on most days (67), limiting the number of meals from fast food

restaurants (69) and demonstrating appropriate levels of dietary restraint and emotional eating (66). The National Weight Control Registry (NWCR) established in 1994, has explored the behavioural characteristics associated with weight loss maintenance in over 5 000 individuals (156). As the NWCR recruits individuals who have lost at least 30 pounds (13.6 kilograms) and maintained that weight loss for at least one year (156), it only identifies the behavioural factors associated with successful weight loss and/or weight loss maintenance in a cohort of initially successful individuals, not all individuals who attempt weight loss, or seek treatment. The identification of behavioural factors that are associated with successful weight loss, among all individuals who seek treatment, is imperative to the development of evidence-based strategies to incorporate into obesity treatments or to introduce at the end of weight loss treatment in order to improve their overall impact long-term.

Therefore, the aims of the current study were to (i) examine the prevalence of successful weight loss 15-months post-enrolment in a commercially available web-based weight loss program; and (ii) to determine behavioural factors associated with successful weight loss 15-months post-enrolment.

7.2 Method

7.2.1 Participants and setting

The commercial web-based weight loss program (The Biggest Loser Club Australia) was a 12-week program, but participants could choose to subscribe for a longer duration to assist with further weight loss and/or maintenance. The program has been described in detail previously. Briefly, the web-based platform developed by SP Health Co. incorporated key evidence-based weight management strategies with features that align with the key elements of social cognitive theory including self-management, social support, self-efficacy, outcome expectations and expectancies, and perceived barriers/facilitators

Enrolees were aged 18 to 75 years and had a BMI≥22 kg/m2, based on self-reported height and weight. Enrolees purchased subscription plan(s) of 1, 3, 4 or 12-months duration. In 2007/08 a subscription cost $AU16.50 to $AU79.95 per month, and was dependant on the number of months a participant subscribed. Participants could subscribe to more than one subscription plan over time and it did not have to be consecutive to the previous subscription. Participants were eligible for inclusion in the current study if they paid for their first subscription between August 15th 2007 and May

31st 2008 and agreed at enrolment to being contacted for possible participation in future research.

7.2.2 Recruitment

Eligible participants were invited to participate in an online survey via a personalised e-mail from SP Health Co. sent 15-months post the participants' initial enrolment. The invitation email provided a link complete the online survey or opt-out if they did not wish to participate. Participants who did not complete the survey or chose to opt-out within 2 weeks of the initial invitation were sent weekly e-mail reminders for up to 3 weeks. Participants who completed the survey received a free calorie counter valued at $AU7.95.

7.2.3 Data collection

All data were collected by SP Health Co. and provided to the researchers in de-identified form. Data were predominantly collected from the online survey which included 32 questions related to the participant's weight status, eating and activity behaviours, weight control practices and intervention satisfaction (Appendix 4). The survey took participants approximately 10 minutes to complete. The survey was pilot-tested in a convenience sample of adults (n=10) and refined prior to commencement to ensure that there was clear and consistent understanding of the questions by respondents, the survey had a logical flow of questions, the administration and data collection were accurate, and to determine the average time taken to complete the survey.

Additional data utilised for the study included responses from a pre-treatment survey (Appendix 2) completed during participants' initial enrolment to the commercial web-based weight loss program, which included self-reported anthropometric and demographic data. Data regarding the membership history of each participant within the initial 15-months of membership (e.g. date of enrolment, date membership ceased and the type of subscription plans held) were also collected.

Ethics approval for the study was obtained from the University of Newcastle Human Research Ethics Committee

7.2.4 Measures

Weight loss success

Weight change (absolute and percentage) achieved at 15-months post-enrolment was calculated by subtracting the participants' weight reported in the online survey from

their pre-treatment weight. Participants were categorised as successful if they achieved a percentage weight loss of ≥5% from initial enrolment to 15-months. A weight loss of ≥5% was selected, as it has previously been recommended as the criteria to evaluate weight management programs (157), and has also been shown to be associated with improvements in weight-related morbidity, particularly reduced incidence of type 2 diabetes mellitus (6, 14, 24).

Behavioural factors

The online survey assessed behaviours previous associated or hypothesised to be associated with weight loss and/or weight loss maintenance.

The survey included short-dietary questions previously developed and validated as part of the Australian National Nutrition Survey (158, 159), to ascertain frequency and/or quantity of intake of key foods and food groups (breakfast, take-away food, restaurant meals, soda, fruit and vegetables). Participants were also asked if they partook in specific eating habits (i.e. Do you do any of the following? Please tick all that apply. Fry foods; Use butter in cooking; Drink tea or coffee with sugar; Use low-fat products where possible; Skip meals; Keep snack foods in the house; Drink 6 or more glasses of water per day).

Responses to two questions regarding frequency and quantity of alcohol consumption categorised usual alcohol intake related risk, based on Australian alcohol consumption guidelines (160). Alcohol intake was defined as 'low risk' if a maximum of one to two drinks were consumed on any drinking occasion, as 'moderate risk' if three to four drinks were consumed on any drinking occasion, as 'high risk' if more than four drinks were consumed on any drinking occasion, or as 'no risk' if they did not consume alcohol.

Dietary restraint, emotional and uncontrolled eating were assessed using the Three Factor Eating Questionnaire-R18, and scores were calculated as previously described by de Lauzon *et al*. (161).

Physical activity level was estimated using the validated International Physical Activity Questionnaire (IPAQ) short format (162). Responses were categorised as low, moderate or high levels of physical activity based on the estimated time spent walking or in moderate or vigorous intensity activity (163). The number of minutes participants reported sitting per day was used as a marker of sedentary behaviour.

Frequency of self-monitoring of weight, food and exercise were independently assessed on a seven point likert scale ranging from never to several times per day.

Socio-demographic and program-related factors

Socio-demographic characteristics from the pre-treatment survey included anthropometric (weight and height) and demographic (age, gender and postcode) data. Self-reported height and weight were used to calculate BMI (weight [kg]/height [m]2). Reported postcodes were assigned an IRSAD tertile (1-10) (141) as an indicator of socio-economic status, as well as an ARIA (142) to classify the level of remoteness of the area the participant lived.

The total number of different weight loss strategies used in the previous 15-months, other than the website were calculated (e.g. other commercial programs, meal replacements, fad diets, diet books or manuals, other web-based programs, surgery, medications, and consultations with health professionals). Satisfaction with the commercial web-based weight loss program was also assessed using a five point likert scale ranging from extremely satisfied to extremely dissatisfied).

7.2.5 Analysis

Data analysis was undertaken using Stata 11.0 (StataCorp, College Station, Texas, USA), with *p*-values less than 0.01 considered statistically significant, due to the large number of comparisons being made. Basic descriptive statistics (median [IQR] for continuous variables, and percentages for categorical variables) were used to describe participants socio-demographic characteristics at enrolment, weight change from baseline to 15-months, program-related factors, and behavioural factors. Categorical variables were collapsed to a smaller number of responses if a low number of participants responded in the extremes of the response range.

Differences in socio-demographic characteristics at enrolment of survey responders/non-responders, as well as differences in socio-demographic characteristics at enrolment, program related factors, and potential behavioural predictors between successful and unsuccessful participants were tested using Two-sample t-tests for normally distributed or Wilcoxon rank-sum tests for non-normally distributed continuous variables and chi-squared tests for categorical variables. Differences in weight change (absolute and percentage) from baseline to 15-months by length of membership to the program (≤6-months, >6- to ≤12-months, >12-months) were tested using Kruskal Wallis test for equality of populations for continuous variables and chi-squared tests for categorical variables.

Univariate logistic regression was conducted to assess the association of behavioural factors with successful weight loss. Behavioural factors with $p<0.2$ were tested for inclusion in the multiple logistic regression model using a stepwise approach. Socio-

demographic and program-related factors found to be significantly associated with weight loss success in the univariate analysis were also included in the multiple logistic regression model, due to potential confounding, as well as known confounders (baseline BMI, age, ethnicity, gender). If any two behavioural or confounding factors were found to be significantly correlated ($p<0.05$, $r>0.7$), the factor most significantly associated with successful weight loss from the univariate analysis was included in the model. Self-monitoring of food and exercise had a significant association, as did the total number of membership days, and the number of days since enrolment. Therefore, only self-monitoring of exercise and the total number of membership days were tested in the multivariate model.

Participants who completed the online survey but did not report their weight, or reported that they were currently pregnant or had been pregnant in the previous 15-months were excluded from the analysis.

7.3 Results

7.3.1 Participant characteristics and response rates

Of the 11341 individuals who paid for their first subscription, 5625 agreed to participate in research and were invited to participate in the online survey (Figure 7.1). These individuals were significantly older, had a higher BMI at enrolment and were of lower IRSAD, than those who did not agree to participate in further research ($p<0.001$). A higher proportion of eligible participants were of Anglo-Saxon descent, and a lower proportion were from major cities of Australia ($p<0.001$).

Twelve percent (n=677) of eligible participants completed the survey. Sixty-eight percent did not respond to the survey invitation, 17% did not receive the email invitation to participate, and 3% reported they did not wish to complete the survey. Sixty-three participants were excluded from the analysis as they did not report their weight in the online survey (n= 17) or because they were or had been pregnant (n=46) since joining the program (Figure 7.1).

Table 7.1 describes pre-treatment socio-demographic characteristics by survey response/non-response. Those who completed the survey had a higher baseline BMI and a higher proportion was Anglo-Saxon. It was intended that the survey be completed 15-months post-enrolment (i.e. ~450 days). On average the survey was completed 486 days after enrolment, and ranged from 447 to 538 days. Most survey completers (41%) subscribed to the program for 3-months or less.

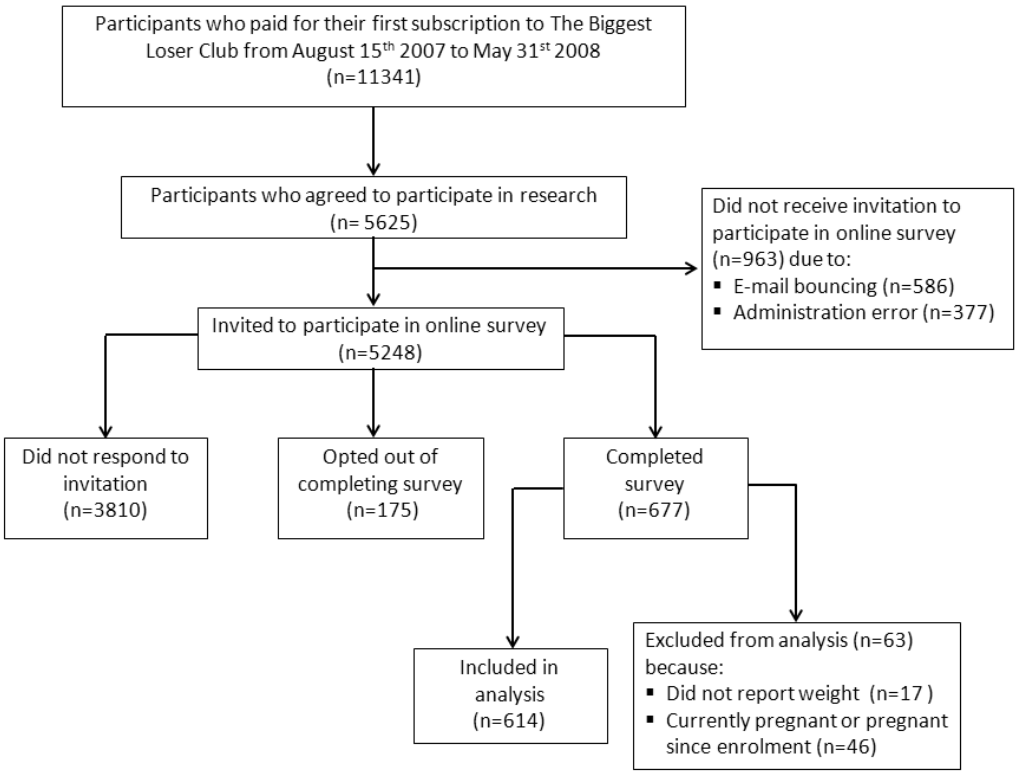


Figure 7.1 Participant flow

Table 7.1 Pre-treatment characteristics of a commercial web-based weight loss program cohort by survey completion status

	Completed n=614	Did not complete n=5011	*p*-value
Age (years)			
Median (IQR)	38.3 (32.0-36.2)	35.2 (29.0-41.7)	<0.001[a]
Gender			
Female, % (n)	88.0 (540)	87.4 (4381)	0.71[b]
Male, % (n)	12.1 (74)	12.6 (630)	
BMI (kg/m^2)			
Median (IQR)	32.7 (29.0-38.1)	32.4 (28.5-37.6)	0.07[a]
Ethnicity			
Anglo-Saxon, % (n)	73.1 (449)	63.1 (3164)	<0.001[b]
European, % (n)	11.2 (69)	14.9 (746)	
Other, % (n)	2.9 (18)	3.2 (161)	
Did not wish to respond, % (n)	12.7 (78)	18.8 (940)	
Socioeconomic status (IRSAD)			
1-2, % (n)	6.7 (40)	6.6 (327)	0.687[b]
3-4, % (n)	9.3 (56)	10.1 (496)	
5-6, % (n)	20.5 (123)	18.9 (931)	
7-8, % (n)	30.7 (184)	29.2 (1442)	
9-10, % (n)	32.8 (197)	35.2 (1736)	
Remoteness (ARIA)			
Major City, % (n)	73.0 (438)	74.3 (3665)	0.356[b]
Regional/Remote, % (n)	27.0 (162)	25.7 (1268)	

[a]Wilcoxon rank-sum [b]Chi-squared

7.3.2 Weight change from enrolment to 15-months

The median (IQR) 15-month weight change was -2.0kg (-8.0-1.8) or -2.7% (-8.2-1.6) of enrolment weight. Just over a third of participants (37%) achieved a weight loss of ≥5% and were therefore classified as successful (Table 7.2). The degree of weight loss increased significantly as the length of membership increased. That is a median (IQR) weight change of -4.4% (-10.7, -0.5) was achieved by those who were members for greater than 12-months, with 47% achieving a weight loss of ≥5%, whereas a median (IQR) of -0.9% (-5.7, -2.9) was achieved by those who were members for ≤ 3-months, of which 28% achieved a ≥5% weight loss.

Table 7.2 Self-reported weight change from enrolment to 15-months in a commercial web-based weight loss cohort

Weight change from enrolment to 15-months		**Total n=614**	**Membership length (months)**			
			≤3 n=249	**>3 to ≤6 n=91**	**>6 to ≤12 n=91**	**> 12 n=183**
Absolute[a] (kg)	Median (IQR)	-2.0 (-8.0-1.8)	-1.0 (-5.0-2.2)	-1.2 (-6-1.4)	-4.0 (-10.1-0.0)	-3.9 (-12.0-0.5)
Percentage of baseline (%)[a]	Median (IQR)	-2.7 (-8.2-1.6)	-0.9 (-5.7- 2.9)	-1.7 (-6.5-1.7)	-3.9 (-11.1-0.0)	-4.4 (-10.7-0.5)
Percentage change from baseline by defined categories[b]	>0% (%)	33.9	39.8	38.5	24.2	28.4
	≤0 to >-5% (%)	29.5	32.5	27.5	31.9	25.1
	≤-5% to >-10% (%)	16.1	14.9	16.5	12.1	19.7
	≤-10% to >-15% (%)	10.9	8.8	5.5	19.8	12.0
	≤-15% (%)	9.6	4.0	12.1	12.1	14.8

[a] Significant difference (p=0.001) between membership length categories (Kruskal Wallis)
[b] Significant difference (p<0.001) between membership length categories (Chi-squared)

7.3.3 Differences between successful and unsuccessful participants

Table 7.3 describes differences in socio-demographic characteristics and program-related factors by successful and unsuccessful participants. Successful participants had been a member of the program for significantly more days, and therefore completed the survey fewer days since their last membership. Successful participants were less likely to have used other additional weight loss strategies in the previous 15-months.

Table 7.4 describes differences in behavioural factors by successful and unsuccessful participants. A higher proportion of successful participants reported more frequent self-monitoring of weight, dietary intake and exercise. A higher proportion of successful participants met the recommended intake targets for vegetable and fruit consumption (i.e. five and two serves per day, respectively). Successful participants were less likely to report current unhealthy eating habits such as skipping meals, keeping snack foods

in the house, eating take-away foods, drinking soft drink and not regularly consuming breakfast. Successful participants also had significantly lower uncontrolled and emotional eating scores, as well as higher dietary restraint scores. A higher proportion of successful participants reported high levels of physical activity.

Table 7.3 Socio-demographic and intervention factors by successful and unsuccessful participants in a commercial web-based weight loss cohort

	Successful n=225	Unsuccessful n=389	*p*-value
Age (years)			
Median (IQR)	38.0 (31.5-45.7)	38.5 (32.0-46.3)	0.86[a]
Gender			
Female, % (n)	85.3 (192)	89.5 (348)	0.13[b]
Male, % (n)	14.7 (33)	10.5 (41)	
BMI (kg/m^2)			
Median (IQR)	34.1 (29.4-39.4)	32.3 (28.7-36.8)	0.02[a]
Ethnicity			
Anglo-Saxon, % (n)	74.2 (167)	72.5 (282)	0.054[b]
European, % (n)	13.8 (31)	9.8 (38)	
Other, % (n)	3.6 (8)	2.6 (10)	
Did not wish to respond, % (n)	8.4 (19)	15.2 (59)	
Socioeconomic status (IRSAD)			
1-2, % (n)	6.4 (14)	6.8 (26)	0.93[b]
3-4, % (n)	10.5 (23)	8.7 (33)	
5-6, % (n)	20.5 (45)	20.5 (78)	
7-8, % (n)	29.1 (64)	31.6 (120)	
9-10, % (n)	33.6 (74)	32.4 (123)	
Remoteness (ARIA)			
Major City, % (n)	74.6 (164)	72.1 (274)	0.51[b]
Regional/Remote, % (n)	25.5 (56)	27.9 (106)	
Days since enrolment			
Median (IQR)	484 (470-494)	488 (474-499)	<0.001[a]
Days a member in previous 15-months			
Median (IQR)	214 (92-395)	121(91-366)	<0.001[a]
Days since last membership			
Median (IQR)	126 (0-379)	333 (84-396)	<0.001[a]
Other weight loss strategies used in the previous 15-months			
None, % (n)	47.1 (106)	34.7 (135)	<0.001 [b]
1, % (n)	35.1 (79)	30.6 (119)	
2, % (n)	12.0 (27)	17.5 (68)	
3 or more, % (n)	5.8 (13)	17.2 (67)	
Intervention satisfaction			
Satisfied, % (n)	79.6 (179)	70.2 (273)	0.03 [b]
Neutral, % (n)	17.3 (39)	23.9 (93)	
Dissatisfied, % (n)	3.1 (7)	5.9 (23)	

[a] Wilcoxon rank-sum [b] Chi-squared

Table 7.4 Behavioural factors by successful and unsuccessful participants in a commercial web-based weight loss program cohort.

	Successful n=225	Unsuccessful n=389	*p*-value
Self-monitoring: Weight			
Less than once per month or never, % (n)	11.1 (25)	26.2 (102)	<0.001[a]
Less than once per week, % (n)	9.8 (22)	7.7 (30)	
Once per week, % (n)	38.7 (87)	30.6 (119)	
More than once per week, % (n)	21.8 (49)	17.7 (69)	
At least once per day, % (n)	18.7 (42)	17.7 (69)	
Self-monitoring: Food			
Less than once per month or never, % (n)	47.6 (107)	60.2 (234)	0.002[a]
Less than once per week, % (n)	4.9 (11)	6.2 (24)	
Once per week, % (n)	4.0 (9)	5.4 (21)	
More than once per week, % (n)	12.4 (28)	10.5 (41)	
At least once per day, % (n)	31.1 (70)	17.7 (69)	
Self-monitoring: Exercise			
Less than once per month or never, % (n)	43.1 (97)	59.4 (231)	<0.001[a]
Less than once per week, % (n)	6.2 (14)	5.1 (20)	
Once per week, % (n)	7.1 (16)	5.7 (22)	
More than once per week, % (n)	12.0 (27)	12.6 (49)	
At least once per day, % (n)	31.6 (71)	17.2 (67)	
Vegetable intake			
<2 serves per day, % (n)	35.6 (80)	48.3 (188)	0.009[a]
2 to 4 serves per day, % (n)	50.2 (113)	40.1 (156)	
5 or more serves per day, % (n)	14.2 (32)	11.6 (45)	
Fruit intake			
<1 serve per day, % (n)	22.7 (51)	31.9 (124)	0.026[a]
1 serve per day, % (n)	33.3 (75)	33.2 (129)	
2 or more serves per day , % (n)	44.0 (99)	35.0 (136)	
Do you fry foods?			
Yes, % (n)	19.6 (44)	26.5 (103)	0.053 [a]
No, % (n)	80.4 (181)	73.5 (286)	
Do you use butter in cooking?			
Yes, % (n)	19.6 (44)	27.3 (106)	0.033 [a]
No, % (n)	80.4 (181)	72.8 (283)	
Do you skip meals?			
Yes, % (n)	21.8 (49)	42.4 (165)	<0.001[a]
No, % (n)	78.2 (176)	57.6 (224)	
Do you drink tea or coffee with sugar?			
Yes, % (n)	28.4 (64)	32.9 (128)	0.251[a]
No, % (n)	71.6 (161)	67.1 (261)	
Do you use low fat products?			
Yes, % (n)	87.1 (196)	79.4 (309)	0.016[a]
No, % (n)	12.9 (29)	20.6 (80)	
Do you keep snack foods in the house?			
Yes, % (n)	27.1 (61)	44.0 (171)	<0.001[a]
No, % (n)	72.9 (164)	56.0 (218)	
Drink 6+ glasses of water a day			
Yes, % (n)	62.7 (141)	44.0 (171)	0.108[a]
No, % (n)	37.3 (84)	56.0 (218)	
Breakfast consumption frequency			
<5 days per week, % (n)	9.8 (22)	22.0 (85)	<0.001[a]
5 or more days per week, % (n)	90.2 (202)	78.0 (302)	
Soft drink consumption frequency			
>1 per day, % (n)	6.3 (14)	9.0 (35)	0.004[a]
1 per day, % (n)	5.8 (13)	8.8 (34)	
< 1 per day, % (n)	21.0 (47)	30.4 (118)	
Never, % (n)	67.0 (150)	51.8 (201)	
Take-away food consumption frequency			
>1 time per week, % (n)	7.6 (17)	25.3 (98)	<0.001[a]
1 time a week, % (n)	20.1 (45)	20.6 (80)	

1 to 3 times per month , % (n)	38.4 (86)	29.9 (116)	
1 time per month, % (n)	24.1 (54)	18.3 (71)	
Never, % (n)	9.8 (22)	5.9 (23)	
Restaurant food consumption frequency			
>1 time per week, % (n)	7.6 (17)	10.8 (42)	0.705[a]
1 time a week, % (n)	14.7 (33)	13.1 (51)	
1 to 3 times per month , % (n)	32.1 (72)	33.3 (129)	
1 time per month, % (n)	35.7 (80)	33.0 (128)	
Never, % (n)	9.8 (22)	9.8 (38)	
Alcohol intake			
High risk, % (n)	11.2 (25)	12.4 (48)	0.924 [a]
Moderate risk, % (n)	20.5 (46)	18.8 (73)	
Low risk, % (n)	51.3 (115)	52.6 (204)	
No risk, % (n)	17.0 (38)	16.2 (63)	
Physical activity level			
Low, % (n)	28.5 (61)	41.7 (148)	0.002[a]
Moderate, % (n)	41.1 (88)	38.3 (136)	
High, % (n)	30.4 (65)	20.0 (71)	
Time spent sitting (Minutes/day)			
Median(IQR)	300 (160.7-480)	360 (180-500)	0.04[b]
Restraint score			
Mean (SD)	15.2 (2.0)	14.4 (2.0)	<0.001[c]
Emotional eating score			
Mean (SD)	7.2 (2.5)	8.4 (2.5)	<0.001[c]
Uncontrolled eating score			
Median (IQR)	20 (18-22)	22 (19-24)	<0.001[b]

[a]Chi-squared [b]Wilcoxon rank-sum [c]Two-sample T-test

7.3.4 Multivariate analysis of successful weight loss

Table 7.5 outlines the behavioural factors found to be independently associated with successful weight loss. Compared to participants who reported weighing themselves infrequently (never to less than once per month), those who weighed themselves more frequently were more likely to be successful. Participants who weighed themselves less than once per week but more than once per month had the highest odds of being successful. Participants who ate take-away foods less than once per week were more likely to be successful, particularly those who never consumed take-away foods. Participants who did not skip meals or keep snack foods in the house, as well as those with higher dietary restraint scores were also significantly more likely to be successful. The higher a participant's emotional eating score the less likely they were to be successful.

7.4 Discussion

The aim of this study was to firstly examine the prevalence of successful weight loss at 15-months post-enrolment in a commercial web-based weight loss program. The study is one of only a small number (122, 124-126) to investigate the long-term weight loss achieved by participants of a commercial weight loss program, and the first to evaluate this for a commercial web-based program. We found that just over a third of participants achieved a weight loss of ≥5% 15-months post-enrolment. Our study also

identified key behavioural factors that were associated with the likelihood of successful weight loss 15-months post enrolment. These included regular self-monitoring of weight, not skipping meals, not keeping snack foods in the house, infrequent take-away food consumption, less emotional eating and greater dietary restraint. These findings highlight strategies that can be incorporated in treatment programs to try and improve weight loss and maintenance of lost weight in the long-term.

Table 7.5 Behavioural factors independently associated with successful weight loss in a commercial web-based weight loss program cohort

	Odds ratio (95% CI)	*p*-value
Self-monitoring of weight		
Less than once per week	4.31 (1.88, 9.85)	0.001
Once per week	2.66 (1.45, 4.87)	0.002
More than once per week	2.95 (1.50, 5.80)	0.002
At least once per day	3.01 (1.50, 6.05)	0.002
Do you skip meals?		
No	2.18 (1.39, 3.41)	0.001
Do you keep snack foods in the house?		
No	1.97 (1.28,3.02)	0.002
Take-away food consumption frequency		
1 to 3 per month	3.63 (1.84, 7.17)	<0.001
1 per month	3.31 (1.54, 7.11)	0.002
Never	4.56 (1.72, 12.08)	0.002
Eating patterns score		
Dietary restraint	1.18 (1.06, 1.31)	0.002
Emotional eating	0.84 (0.77, 0.91)	<0.001

Adjusted for Gender, baseline BMI, Age, Ethnicity, days since membership, total membership days, intervention satisfaction and number of other weight loss strategies (n=601).

Over one third of participants in the commercial web-based weight loss program achieved a clinically important weight loss at 15-months post-enrolment, thereby reducing their risk of weight-related morbidity such as type 2 diabetes mellitus (6, 14). Furthermore, the proportion of participants who achieved ≥5% weight loss increased significantly as membership length increased. As many participants (41%) subscribed to the program for less than 3-months, a potential strategy to improve long-term weight loss is to encourage participants to subscribe for longer, or to offer a longer (e.g. 6-month) minimum subscription length. This is consistent with other research that suggests that the greatest level of weight loss is achieved after 6-months of treatment (155). It is noteworthy, that over 60% of the participants who subscribed for 3-months or less had not regressed to their enrolment weight after one year, as this is commonly the case for behavioural weight loss programs (155). This suggests that a short-term web-based weight loss program has the potential to achieve modest weight loss one year post-enrolment, and prevent weight gain. However, this must be further tested prospectively and objectively in a RCT.

Notably only two RCT (42, 54) and one observational study (65) have assessed participants' maintenance of lost weight following the completion of a web-based weight loss intervention. Morgan *et al*. reported a -5.3kg weight change at 9-months post completion of a 3-month web-based intervention, with 58% of participants achieving a weight loss of ≥5% (54). Rothert *et al*. reported significantly greater weight loss maintenance in a tailored Internet group (-2.7 and -3.0%) compared to an information-only internet group (-1.2 and -1.2%) at 3- and 6-months post-enrolment in a 6-week intervention. Wing *et al*. reported an average weight loss of -3.8% in overweight and obese participants 2-months post completion of a 16-week web-based intervention (65). The magnitude of long-term weight loss reported in the current study may appear low in comparison to the other studies. However these studies only evaluated weight change within a short timeframe after the completion of the intervention (2- to 6-months), and they also included non web-based components (e.g. face-to-face sessions, resources) (42, 54, 65). As many survey participants (41%) in this study subscribed to the program for 3-months or less, many had not participated in the program for approximately one year when they completed the survey, therefore the results are noteworthy.

The results from other long-term follow-up studies of commercial weight loss programs have been varied. After two years, female participants of Mincavi, a group-based face-to-face program reported that approximately 44% of participants maintained ≥5% weight loss (126). Weight Watchers, a group-based face-to-face program, have reported that 70 to 80% of participants who achieved their goal weight maintained ≥5% weight loss after one year (122, 124). The Jenny Craig program, which involves weekly face-to-face individual and group consultations, has reported that among participants who achieved their goal weight, an average weight loss of 12.5kg was sustained after one year (125).The prevalence of successful weight loss reported in the current study may appear low in comparison to other long-term follow-up studies of commercial weight loss programs. However, the participants in the comparison studies are not representative of all enrolees, with three of the studies only including participants who were initially successful at achieving significant weight loss (122, 124-126), and the other study only including female participants (126). Therefore, they cannot be generalised to the whole population of their respective commercial users in terms of degree of long-term weight loss. More specifically, those studies that only include participants who were initially successful may over-estimate the true prevalence of long-term weight loss.

The second study aim was to determine which behavioural factors were associated with successful weight loss 15-months post-enrolment. Self-monitoring of weight was associated with successful weight loss, which is consistent with other research which has demonstrated more frequent self-weighing (daily or weekly) is associated with improved weight loss maintenance (69, 164-166). However, these studies often do not differentiate between less frequent self-weighing categories, and group frequencies such as less than once per month and less than once per week together. Our study included a greater number of self-weighing frequency categories and demonstrated that participants who weighed themselves less than once per week, but more often than once per month, had the greatest odds of being successful. This suggests that more frequent self-weighing (e.g. 1 or more times per week or day) may not be essential to achieve clinically important weight loss in the long-term.

Eating patterns play an important role in long-term weight loss success, with higher levels of dietary restraint and lower levels of emotional eating associated with maintenance of lost weight (164, 167-170). The results from our study are consistent, demonstrating that for each one point increase in the emotional eating score, the likelihood of being successful decreased by 16%, whereas for each one point increase in restraint score the likelihood of being successful increased by 18%. Therefore, strategies to assist individuals to manage emotional eating and to strengthen dietary restraint are required. Recent studies have demonstrated that behavioural interventions can produce positive changes to participants' eating patterns (168) but further research is required to determine the most effective strategies to ensure long-term weight loss.

Previous studies have demonstrated that successful weight loss is associated with consistent eating patterns and regular breakfast consumption (67, 171). While unable to demonstrate that consuming breakfast was significantly associated with success, we found that skipping meals was associated with a lack of success. Therefore, it may be not be skipping breakfast specifically that is the problem, but rather skipping any meals. It has also been suggested that reduced frequency of snacking is associated with weight loss (172). Our study suggests that the availability of snack foods within the home environment may also negatively affect weight loss. Finally, adults who report consuming food from fast-food restaurants more than twice per week have been shown to be less successful at weight loss maintenance (69). Our study suggests that reducing take-away food consumption to less than once per week significantly increases the likelihood of successful weight loss, with no take-away food consumption being most ideal. Both studies support the recommendation that the frequency of

consumption of fast-food and/or take-away needs to be reduced to support long-term weight loss.

7.4.1 Limitations

To maximise external validity our study aimed to recruit participants who were representative of the consumers who take part in a commercial web-based weight loss program. Inclusion in our study was not dependant on achieving a goal weight or having a significant weight loss or whether individuals completed or used the web-based program, as is the case with other similar studies. Survey responders were similar to non-responders for most pre-treatment characteristics. However, program enrolees who agreed to be contacted to participate in research were older, with higher BMI, of lower SES, and more likely to be Anglo-Saxon or from regional/remote areas of Australia. The survey response rate was also low. However, a similar study that followed-up participants' 12-months post-enrolment in web-based weight loss program via an online survey achieved a similar response rate (15%)(173). Therefore, the results for this study may misrepresent the prevalence of successful weight loss 15-months post-enrolment among all program enrolees. The response rate and representativeness of future research could potentially be improved with different recruitment strategies, offering alternate methods of survey completion (e.g. telephone, mail) or greater incentives.

Other potential limitations of this study include that all outcomes were self-reported. To reduce measurement bias validated questionnaires (e.g. IPAQ, 3 Factor Eating Questionnaire-R18, short-diet questions) were used where possible. Self-reported weight data was used to evaluate success, and weight can be under-reported (174). However, self-reported weight recorded by participants of a web-based weight loss program has been found to be accurate compared to measured weight (175).

In addition, the study considers behavioural factors cross-sectionally and does not capture pre-treatment or changes in behaviours. Therefore, the analysis demonstrates which behaviours at 15-months are associated with successful weight loss but cannot determine whether the participants improved their behaviour to achieve weight loss, or behavioural characteristics remained the same and success could have been predicted at baseline.

7.4.2 Conclusion

The findings suggest that over one third of participants in a commercial web-based weight loss program achieved clinically important weight loss 15-months post-

enrolment, and that participating in the program for 6-months or longer was associated with greater weight loss. The findings also provide support for existing recommendations, as well as propose novel strategies, to be incorporated within obesity treatments to improve the likelihood of successful weight loss outcomes in the long-term. More specifically the finding suggest individuals trying to achieve or maintain ≥5% weight loss should be advised to regularly weigh themselves, avoid skipping meals or keeping snack foods in the house, and to limit the frequency of take-away food consumption. Furthermore, strategies to assist individuals to manage emotional eating and to strengthen dietary restraint should also be incorporated within obesity treatments.

Chapter Eight: Comparison of energy intake estimated by a web-based food diary to total energy expenditure determined by the doubly labelled water method in overweight and obese women.

This paper was submitted for consideration for publication in July 2011, and is currently under peer review by the *Journal of the American Dietetic Association,* as a Research and Professional Brief.

The authors of the paper are Neve MJ, Truby H, Collins CE, Morgan PJ, Davies PS and Callister R. The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 10).

8.1 Introduction

Food diaries are widely used for self-monitoring in weight loss interventions and to assess changes in dietary intake as an outcome measure in intervention studies (130). Food diaries require participants to record the type and quantities of foods and beverages consumed, and have traditionally been completed in paper-based form (129, 133). They offer several benefits to the respondent and to researchers compared to other dietary intake measurement tools. As they are prospective, they are less reliant on respondents' memory, thereby reducing recall bias (130, 133). They also allow for completion at the time the food or drink is consumed, in an open-ended format (130, 133).

However, food diaries are labour intensive and require high levels of motivation and moderate literacy skills, which result in a substantial respondent burden. This burden, as well as social desirability, may alter an individual's usual eating habits during the recording period (130, 133). The tendency to backfill, where respondents complete their food diary some time after food consumption, may also introduce recall bias (131). Therefore, food diaries may not accurately portray an individuals' dietary intake. Importantly, interpretation of the data requires access to a nutrient database or reference in order to obtain an estimate of the energy or nutrient values of the consumed foods and beverages. This usually requires input from a range of other individuals, including dietitians, which limits the utility for self-monitoring, and increases the resources required (e.g. time and cost) (130).

Web-based weight management interventions have emerged in recent years as a weight loss intervention medium. A recent systematic review of web-based weight management interventions found that all but 1 of the 18 included studies offered web-based self-monitoring tools (Chapter Three) and many provided a web-based food diary (25, 36-40, 43, 46, 47, 51). Web-based food diaries have the potential to reduce respondent burden by simplifying recording and reducing diary completion time (130, 176). They increase the speed with which feedback can be provided on entries, including real-time feedback, which may improve motivation. However, this feedback may change the type of food and drinks respondents' record, and therefore may not accurately portray respondents' usual dietary intake (130). Also, they may still be susceptible to entry bias. Therefore, web-based food diaries have both strengths and weaknesses compared to traditional paper-based diaries, which may influence their potential accuracy.

While there is strong evidence that respondents commonly misreport their EI when completing a paper-based food diary (133, 177-179), there are no published studies reporting the accuracy of web-based food diaries. Studies comparing EI derived from paper-based food diaries to an objective measure of TEE indicate that misreporting of EI is prevalent (133, 177-179), and EI is under-estimated by 4% to 37% (133). Furthermore, women and those who are overweight or obese are more likely to under-report EI and to a greater extent (177, 178). Therefore, this study aims to evaluate the accuracy of EI estimated by a web-based food diary by comparison with TEE obtained by DLW, in weight stable overweight or obese women. We hypothesised that the women would under-report their EI to a similar extent to paper-based diaries (i.e. 4% to 37%) (133).

8.2 Methods

8.2.1 Subjects

Overweight or obese women aged 18 to 60 years who were staff or students of The University of Newcastle, NSW, Australia were recruited in June 2008. Eligibility criteria included: computer and Internet access; self-reported moderate level of computer skills; passing a pre-exercise intervention health screen (180); no history of major medical problems; no recent weight loss of 4.5kg or more; no current medications that influenced weight loss, and no pregnancy or lactation. The inclusion criteria were specific to reduce heterogeneity given the high cost of the DLW technique, and because the participants entered a weight loss intervention after completion of this study. This population was selected as are representative of enrolees of the commercial web-based weight management intervention of which the web-based food diary is a component, as published previously (Chapter Four).

8.2.2 Study design and data collection

In this study, data collection occurred over a 10-day period during July 2008. Participants attended the university laboratory on the 1st and 10th days of the data collection period and fasted overnight prior to day 1. Participants were asked to remain weight stable throughout the data collection period and to maintain their usual diet and physical activity habits, as TEE only represents EI in the presence of weight stability.

8.2.3 Measures

Web-based food diary

The diary was a self-administered pre-coded estimated food diary. It forms a component of a commercial web-based weight management program (SP Health Weight Loss Platform) and was developed as a tool to self-monitor dietary intake. Participants completed the web-based diary for 9 days (Day One to Nine). They were provided with a 30-minute face-to-face group session prior to commencing the study to learn how to use the web-based diary. The session was conducted by a dietitian from SP Health. Participants were instructed to enter the type and quantity of all food and drinks consumed and to estimate the quantity of each food or drink item but were not expected to weigh or measure items. Participants used the online food database to search for the individual food and drink items they consumed. They selected the most appropriate food or drinks from a list of items generated automatically by the database by matching the letter(s) in the search term(s) to the items in the database. Food and drinks were entered in the diary as individual items, or pre-created food and drink combinations were selected. If participants were unable to find an exact match they were able to create their own combinations or recipes by merging individual food or drink items. All food and drink items were pre-coded for EI using data obtained from a commercial Australian database which modelled nutrient values from the Nutrient Data Tables for use in Australia (NUTTAB) 1995, as well as other sources including manufacturer's data. Participants were provided with real-time feedback (i.e. automatic feedback) on their dietary intake via the web program, through presentation of the caloric value of each item entered, as well as cumulative EI for the day. Data from the diary entries were provided to the researchers by SP Health Co. Daily diary entries were classified as having been completed if two or more meals were entered and the average EI per day was calculated using data from complete daily diary entries only.

Doubly labelled water

TEE was measured using the DLW method as described by Schoeller DA (181). Pre-dose urine collected on Day 1 was used for correction of background isotope levels. Subjects were then given a loading dose of DLW ($^{2}H_{2}{}^{18}O$) based on their total body water (kg) corresponding to 0.083g $^{2}H_{2}$ (99.8 atom % excess; Sigma Aldrich, Milwaukee, WI) and 2.083g ^{18}O (10 atom % excess; Taiyo Nippon Sanso, Yokogawa, Japan), with TBW predicted by bioelectrical impedance analysis (BIA) (Impedimed™ SFB7 for Body Composition, Queensland, Australia)**.** A spot urine sample was collected after 5 hours and then daily for the next 9 days by participants who recorded

the time of each sample. Urine samples were stored frozen until analysed on an Isoprime Dual Inlet Stable Isotope Ratio Mass Spectrometer (DI-SIRMS). All samples were analysed in duplicate with Laboratory standards calibrated against an international suite of waters including Vienna Standard Mean Ocean Water (VSMOW); ^{2}H and ^{18}O being reported in ‰ relative to VSMOW with an analytical uncertainty better than ± 3‰ (1SD) and ±0.5‰ (1SD), respectively. CO_2 production was derived from ^{2}H and ^{18}O disappearance rate constants (22) calculated by least squares regression analysis. TEE was then determined by the DeWier equation using the rates of CO_2 production and the respiratory quotient (182).

Other measures

Height was measured using a Harpenden stadiometer (Holtain Limited, Dyfed, UK) to 0.1 cm on day 1 only. Weight was measured to 0.01kg on a digital scale (CH-150kp, A&D Mercury Pty Ltd, Australia), in light clothing and without shoes, on the 1st and 10th days. Weight change during the data collection period (Day 1 and 10) was calculated. BMI was calculated using the standard equation (weight [kg]/height[m]^{2}).

8.2.4 Analysis

To allow for comparison of TEE derived from the DLW technique and self-reported EI, any participants who did not remain weight stable (±1kg) during the data collection period were excluded from the analysis.

Data are presented as mean ± SD with median and range. Data were analysed using STATA 11.0 (StataCorp, College Station, Texas, USA). The accuracy of the web-based food diary was assessed by calculating the absolute (i.e. EI- TEE) and percentage (i.e. EI/TEE x 100) differences between EI and TEE. The association between EI and TEE was tested using Pearson correlation coefficients and Bland-Altman Plots were produced to visually interpret the agreement between EI and TEE. Participants were identified as under-reporters of EI based on the 95% confidence limits of the expected EI: TEE of 1 (183). The 95% confidence limits were calculated as follows:

$$\pm 2 \times \sqrt{[CV^{2}_{EI}/D)+CV^{2}_{TEE})]}$$

where CV_{EI} was the within subject coefficient of variation (CV) for EI from the web diary (23.4%) and CV_{TEE} was the within subject CV for TEE (8.8%). D was the number of days of dietary assessment (9 days) (183). Therefore, participants with EI: TEE <0.77 were classified as under-reporters of EI and those with EI: TEE>1.23 were classified as over-reporters.

8.2.5 Ethics

Ethics approval was obtained from the University of Newcastle Human Research Ethics Committee and all participants provided written informed consent.

8.3 Results and discussion

This study evaluated how accurately a commercial web-based food diary estimated EI in overweight and obese women. To the authors' knowledge, this is the first study to evaluate the ability of overweight women to self-report EI via a web-based food diary using the gold standard DLW technique. The results indicate that at the group level, EI was under-reported by approximately 20%, and that four of the nine participants under-reported EI. Furthermore, the precision of the measurement of EI was highly variable across the group. This suggests the ability of the web-based food diary to correctly estimate individual EI may be inconsistent.

Twelve participants enrolled in the study and three were excluded from analysis as they did not remain weight stable. Participants who remained weight stable (n=9) had a mean ±SD age of 34.5 ±11.3 years (20 to 47 years). Their weight was 79.6±10.7kg and BMI 29.2±1.4kg/m^2. Eight participants completed diary entries for 9 days and one participant had 8 days of complete entries (i.e. more than two meals recorded each day).

Participants' self-reported EI from the web-based diary was 1996±293kcal/day. Their daily TEE measured using the DLW technique was 2545±424kcal/day. The absolute difference between self-reported EI and TEE was -550±367kcal/day representing a reporting accuracy of 79.6±14.1% (Table 8.1). The Pearson correlation coefficient for EI and TEE was not significant (r=0.53, P=0.14). The EI to TEE ratio was less than 0.77 for four participants who were classified as EI under-reporters; no participants were over-reporters of EI. Figure 8.1 presents a Bland-Altman plot of the difference between EI and TEE against the mean of EI and TEE. The limits of agreement of -1268 to 169kcal/day are wide indicating large discrepancies at the individual level between EI self-reported using the web-based food diary and TEE estimated by the DLW technique.

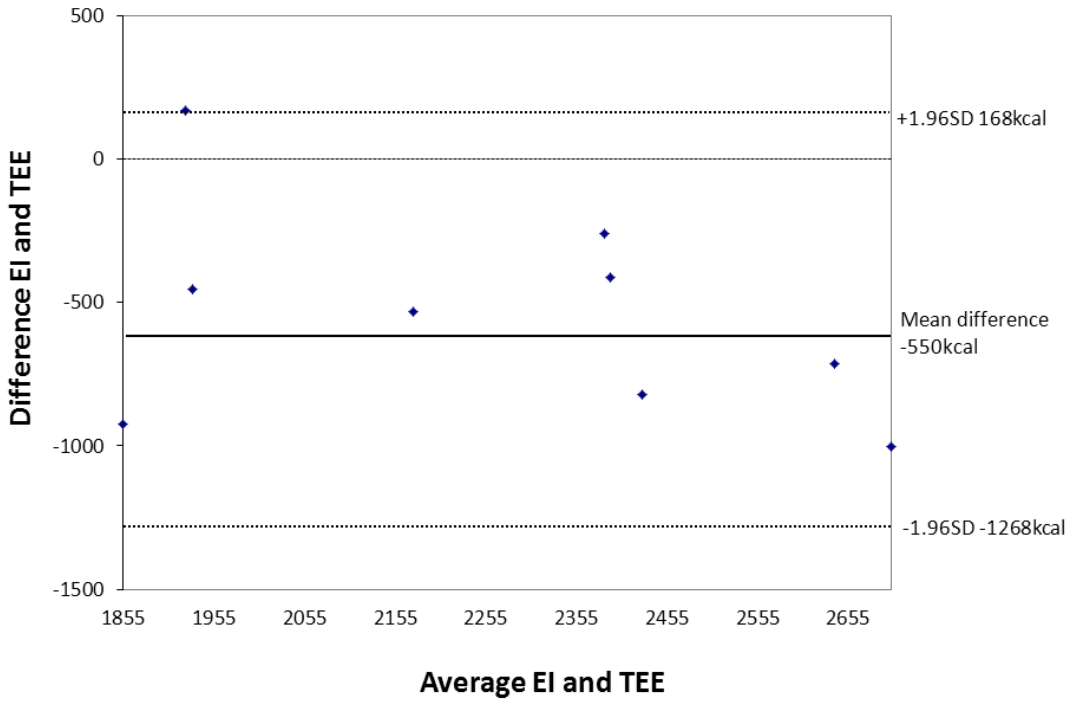
Table 8.1 Comparison of EI measured by web-based food diary to TEE determined with the DLW method.

	Mean (SD)	Median	Range
TEE (kcal/day)	2545(424)	2516	1839 to 3203
EI (kcal/day)	1996(293)	2017	1393 to 2283
EI-TEE (kcal/day)	-550(367)	-533	-1001 to 170
EI/TEE (%)	79.6(14.1)	78.2	60.1 to 109.2

Abbreviations: TEE, Total energy expenditure; EI, Energy Intake

As hypothesised, the findings indicate that the accuracy of web-based food diaries appears to be consistent with that previously reported for traditional paper-based food diaries of 4% to 37% (133). However, the results of the paper-based food diary studies are not directly comparable to our study findings, due to the highly selective and different study populations in those validation studies, as well as dissimilar sample sizes (178). Therefore, further research is required to determine whether any specific food-diary medium provides a more accurate measurement of EI by conducting validation studies directly comparing paper to web-based diaries.

Previous studies evaluating food diaries have typically evaluated tools that were developed for epidemiological or intervention research purposes. These studies use numerous strategies to enhance the completion and accuracy of records including training sessions, reminder phone calls, provision of measurement instruments or handbooks/user guides, and the returned diaries are reviewed and amended by researchers prior to study completion (133). In contrast, the web-based diary evaluated in this study was a commercial tool, participants were provided with only a single brief training session prior to study commencement, and their self-reported food quantities were estimated. The accuracy of the diary could potentially be enhanced through the addition of the strategies employed by other studies to improve completeness of entry with reminders and accuracy by provision of tools to assist with portion size determination.



EI and TEE are expressed in kcal/day. The solid line indicates the mean difference between EI and TEE, the dotted line represents the limits of agreement, and the broken line represent total agreement between EI and TEE (i.e. difference is equal to 0). The individual results are presented as a diamond.

Figure 8.1 Difference between EI from web-based diary and TEE measured using the DLW method

Limitations

The sample size of this study was relatively small due to the cost of the DLW technique. Therefore, a homogenous group of participants comprising overweight or obese young to mid-aged women who are most representative of the usual enrolees of the commercial web-based weight loss program were selected. Consequently, the results may not be applicable to other population groups and are potentially skewed towards under-reporting, given that obese individuals and women are recognised under-reporters (177, 178). Future studies should recruit from a larger, more diverse population to assess the validity of web-based food diaries.

Prospective dietary intake assessment methods also often alter usual dietary intake (129, 133). The web-based food diary adds further complexity to this source of bias by providing real-time feedback on food entries. This feedback may alter the changes made to dietary intake during the data collection period. Therefore, the impact of

feedback provided by web-based food diaries on reporting accuracy should also be evaluated.

This study used data obtained predominantly from NUTTAB 1995 to estimate EI, when a more recent version (2006) was available at the time of the study. The database used also suffers from the limitations of all nutrient composition databases including data being based on an average value for similar food types with no consideration of seasonal or batch variations in nutrient content, and new or altered food products not being captured by the database (132). Therefore, the calculation of EI from the web-based food diary may not be entirely accurate, and may have contributed to the differences between EI and TEE.

8.4 Conclusion

Web-based food diaries offer an alternative to paper-based diaries, as their accuracy in assessing EI may be consistent with previously published paper-based studies. However, web-based food diaries must be further evaluated, in larger and more diverse population groups, and be directly compared to paper-based diaries not only in terms of accuracy, but also their ability to overcome other limitations of paper-based diaries. If the accuracy of EI obtained by paper and web-based diaries is consistent, but web-based diaries have a lower respondent burden, they may be a more appropriate medium for self-monitoring and measurement of dietary intake given the exponential increase in Internet access worldwide (21). There is considerable scope for further development of web-based food diaries to improve their overall accuracy, such as the addition of strategies to increase participant motivation and decrease respondent burden.

Chapter Nine: Discussion and recommendations for research and practice

9.1 Overview

This chapter outlines the key findings of the body of research and compares them to the existing literature in the field (Section 9.2). This includes the findings in relation to: effectiveness (Section 9.2.1); website use, drop-out and non-usage attrition (Section 9.2.2); and reach (Section 9.2.3) of web-based weight management interventions as well as the assessment of dietary intake via the Internet (Section 9.2.4). Section 9.2.5 provides an overall summary of the findings in relation to the hypotheses. The chapter then describes the strengths and limitations of the research presented (Section 9.3). The chapter closes with a summary of the overall implications of the research findings (Section 9.4), and concluding remarks (Section 9.5).

9.2 Summary of findings and discussion

9.2.1 Effectiveness of web-based weight management interventions

The results of the systematic review (Chapter Three) highlighted that, up until April 2008, there were a limited number of published studies to assess the effectiveness of web-based interventions in achieving weight loss (n=13) or weight loss maintenance (n=5). The studies included in the systematic review addressed diverse research questions (e.g. comparing web vs. control, web vs. face-to-face group sessions, and web with face-to-face group sessions vs. web alone) and evaluated distinct web-based intervention strategies (e.g. education materials only, cognitive behavioural therapy). Therefore, only a small number of studies were similar enough to be included in each meta-analysis, and the results were often heterogeneous. Subsequently, the results of the meta-analyses must be interpreted with caution.

To summarise, the meta-analyses demonstrated that web-based interventions achieve similar weight loss to control or minimal intervention groups; web-based interventions with enhanced features achieve greater weight loss than those with education alone; web-based interventions to achieve maintenance of lost weight result in less weight regain than no intervention control groups, and web-based interventions achieve similar levels of weight loss maintenance as face-to-face interventions.

Chapter Five presented results evaluating the weight change achieved in a large cohort of participants of a commercial web-based weight loss program who subscribed for 12- or 52-weeks. Weight change was evaluated using self-reported weight data, which participants entered as part of their usual usage of the program (i.e. weekly weigh-ins). Given the decline in weekly weigh-ins over time, a two-step approach to the statistical

analysis was used (GLMM including all enrolees and sensitivity analysis using LOCF). The study found an average weight change within the range of GLMM and LOCF results (i.e. 12-weeks: -3.0 to -6.2%, 52-weeks: -3.5 to -6.9%). Importantly, this range is within the clinically important benchmark (5% to 10% weight loss) for improvement in weight-related morbidity (6, 14).

Weight change and the prevalence of successful weight loss (≥5%) at 15-months post-enrolment was examined in Chapter Seven. Eligible participants were those of the cohort study who also agreed at enrolment to be contacted for research purposes. They were invited to participate in an online survey (n=5625) 15-months post their initial enrolment date which involved self-reporting their current weight. Median self-reported weight change 15-months post-enrolment was -2.7% among survey respondents (n=614) and just over one third of participants reported ≥5% weight loss since enrolment. Although not directly comparable to the results after 12- and 52-weeks membership, the mean weight change at 15-months, suggests that, as a cohort, weight regain is likely to have occurred. Weight regain was hypothesised, as participants of behavioural weight loss interventions commonly relapse and regain most, if not all, of their lost weight within 1- to 5-years (90). Many of the survey participants (41%) subscribed to the program for 12-weeks or less, and therefore had not participated in the program for approximately 1-year when they completed the survey. Despite this, over 60% of the participants who subscribed for 12-weeks had not regressed to their enrolment weight after 1-year. This suggests that a short-term web-based weight loss program has the potential to achieve modest weight loss 1-year post-enrolment, and prevent weight gain.

Researchers suggest that extended behavioural interventions may be required to achieve long-term weight loss maintenance (184). The findings from this research support this notion, as greater weight losses were reported at 15-months post-enrolment in those with longer periods of membership. Approximately 47% of participants who were members of the program for more than 12-months were categorised as successful participants (≥5% weight loss). Therefore, longer treatment participation may be a key factor leading to successful weight loss in the long-term. However, just over half of the participants who were members of the program for greater than 12-months did not lose 5% of their baseline weight by 15-months post-enrolment. Therefore, simply subscribing for a greater period does not guarantee long-term success, as some participants may require alternative strategies and support.

The commercial weight loss program evaluated in this thesis was solely web-based. The website provided online goal setting, self-monitoring of weight, dietary intake and

exercise with automated feedback, an online discussion forum, as well as educational materials such as weekly tutorials. The program was also predominantly self-directed, which means that participants had no contact with the program providers, other than e-mail weigh-in reminders and tutorials. In addition, the program did not offer a different weight loss maintenance program or alternative strategies that focused specifically on achieving maintenance of lost weight once participants achieved their goal weight. RCTs conducted to date that have evaluated interventions described as solely web-based commonly include additional web and non web-based components not provided by the commercial web-based weight loss program evaluated. The additional web-based components provided by the other solely web-based interventions address many of the key features of web-based weight management interventions previously outlined (Table 2.1). This includes:

- Social support through the use of a buddy program either with other program participants (24) or an external buddy (e.g. family or friend) (42), as well as online meetings (25, 46, 57).
- Provision of feedback predominantly in relation to self-monitoring of dietary intake and exercise, most often individualised and provided via email (25, 36, 39, 43, 46, 55).
- Tailoring the program and information provided to the individual based on pre-treatment screening (42, 45, 53).
- Interactive components including online lessons, homework or meetings (25, 36, 39, 43, 46, 48, 57, 58).
- Structured programs with reminders to self-monitor dietary intake and exercise (43) or use the website (45).

Additional intervention features provided to participants of other web-based interventions, not part of the website, included face-to-face sessions, ranging from one-off sessions in groups (36, 39, 55), to ongoing individual sessions with a psychologist (24), or motivational interviewing either in person or via telephone (51, 52). Program booklets (55) and reimbursement for meal replacements (43) were also provided.

The commercial program evaluated in this thesis does not include all of the key components of behavioural or web-based weight management interventions, previously outlined (Table 1.2 & 2.1). As outlined in Figure 9.1, the program currently addresses social support, self-monitoring, and contingency management, provides feedback and interactive features, and is based on a theoretical framework. The program does not address problem solving, cognitive restructuring or relapse prevention, and is self-

directed, not structured. It also only addresses stress management and stimulus control at enrolment, not throughout the intervention.

As the program does not include all of the key components of behavioural or web-based weight management interventions, and also provides less web and non-web based features than several other web-based interventions investigated to date, the weight change achieved by the program participants was expected to be lower. However, the results for 12- and 52- week subscribers are comparable to the other web-based programs. Therefore, as the commercial web-based weight loss intervention is self-directed, less intensive and involves no additional non-web components, it is a potentially cost-effective strategy with less burden on both the participant and service provider compared to other web-based programs, as well as face-to-face programs. Consequently, the findings suggest that self-directed, low-intensity web-based weight loss programs should be considered as potential treatment medium for overweight and obese individuals.

It is important to note that there is also opportunity to enhance the weight loss achieved, and improve the likelihood of weight loss maintenance through modification of existing program features, as well as the addition of new program features. Figure 9.1 outlines potential improvements and additions to the existing commercial web-based weight loss programs to ensure the key components of behavioural and web-based interventions are adequately addressed. To summarise, the suggested improvements include the addition of:

- Strategies to improve use of the current website features (e.g. email reminders).
- Improved screening of participants at enrolment (e.g. precursors to poor eating and activity habits, demographic characteristics, computer literacy), provision of appropriate program/features to meet their needs (e.g. tailored educational materials) and ongoing assessment of key issues identified as part of the pre-screening process throughout the intervention.
- Acknowledgements when participants achieve weight or behavioural goals (e.g. virtual rewards).

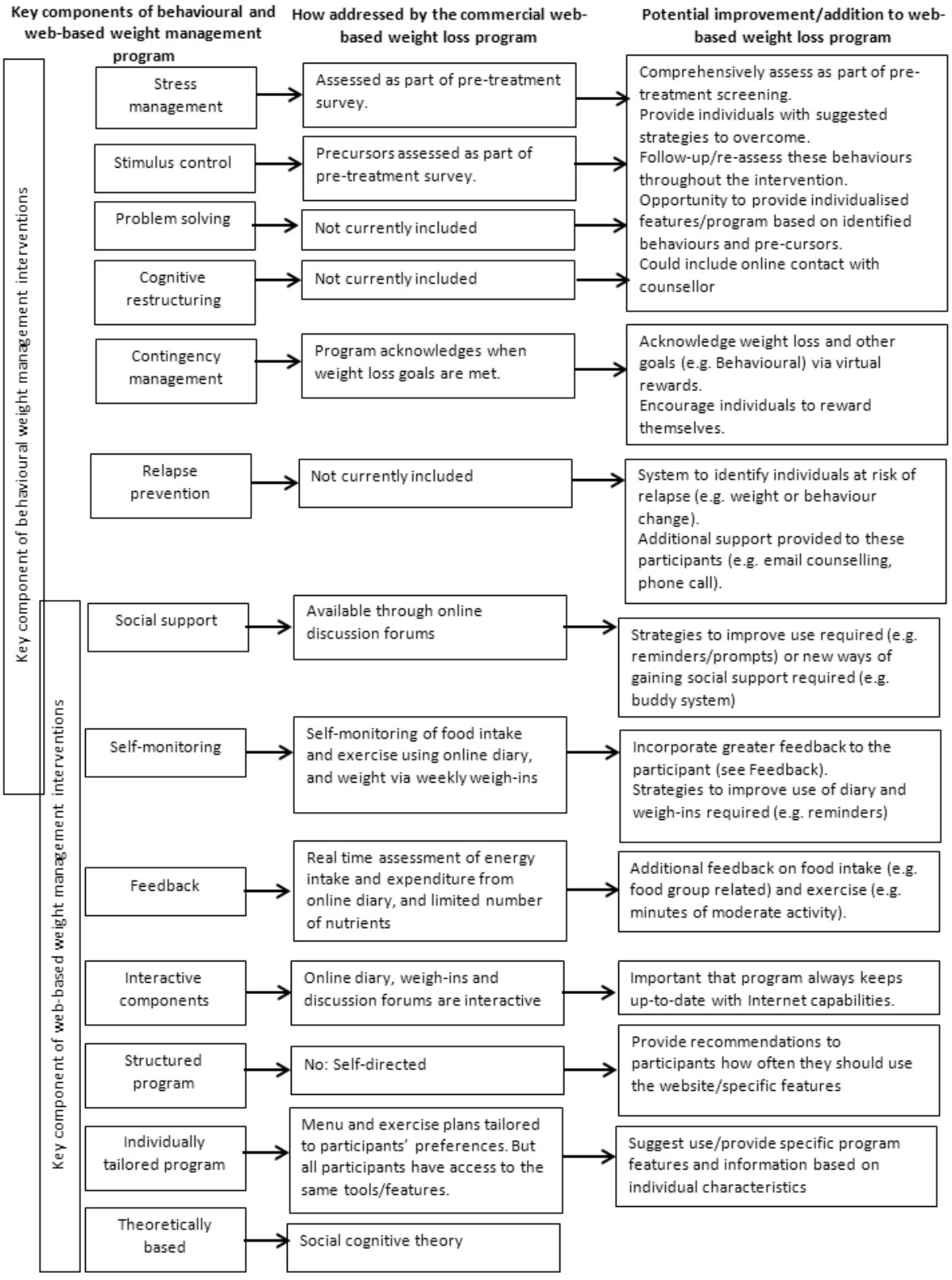


Figure 9.1 Potential changes to the commercial web-based weight loss program

- Improved individualised feedback, particularly in relation to self-monitoring of food, exercise and weight.
- A system to identify and provide additional support (e.g. online individual or group counselling) to participants at risk of relapse or drop-out/non-usage attrition.
- Evidence-based recommendations, based on the findings from the cohort study, on how often participants should engage with or use the web-based program/features to meet their weight loss goals, provided to participants at enrolment, and reiterated throughout the program.

Any potential improvements to weight-related outcomes as a result of changes to the features, content or strategies used, need to be objectively evaluated. Furthermore, any improvement in weight outcomes also needs to be considered relative to changes in program cost-effectiveness, reach, drop-out and non-usage attrition.

9.2.2 Website use, drop-out and non-usage attrition in web-based interventions to treat overweight and obesity

The systematic review (Chapter Three) of web-based weight management interventions found that greater website use (number of log-ins, self-monitoring occasions, chat room attendances, and bulletin board posts) was associated with greater weight loss or weight loss maintenance in the majority of studies that examined this association. This highlights that participants' use of website features is a key component of effectiveness. This is supported by the results from the cohort study reported in Chapter Five. As hypothesised, the frequency of use of all website features (log-ins, diary entries, and forum posts) was correlated with weight change for both 12- and 52-week subscribers. Furthermore, as percentage weight loss category improved the frequency of use of each website feature, as captured by objective website usage data, increased significantly among 12- and 52-week subscribers. Further understanding of how participants use web-based weight management interventions is therefore required, in order to improve effectiveness.

However, an overall evaluation of how participants utilise web-based weight management interventions could not be deduced from the results of the systematic review (Chapter Three). This is because most studies reported findings as an average number of contacts with a particular feature, which does not allow comparison of website use across studies or evaluation of compliance with the intervention over time. The results highlight the need for standardised usage metrics for web-based health interventions. The findings from the cohort study demonstrate how website use can be

reported to allow comparison between web-based interventions and could be used as a standard method of reporting. For example, the study reports use of each website features not only as the median number of days used, but also the proportion of possible days each website feature was used, the number of participants who used each website feature (Chapter Five), and non-usage attrition (Chapter Six).

Results presented in Chapter Five and Six demonstrate the overall use of the commercial web-based weight management program was relatively low and highly variable. The program also had low drop-out (i.e. number of participants who did not complete the program) but high non-usage attrition rates (i.e. number of participants who stopped using the website). The website use and non-usage attrition rates were consistent with other web-based interventions, whereby use declines over time. However, for this commercial program non-usage declined steadily over the 12- and 52-week subscription period, but increased slightly during the final stages. Other studies have reported initial declines in non-usage, with a stable group of users continuing to participate to the end of the intervention (89).

Both the drop-out and non-usage attrition rates demonstrated by the program were potentially influenced by many factors, as previously outlined by Eysenbach (89) This includes:

- information provided at enrolment;
- the type of users who enrolled;
- how easy it is to drop-out or to not use the website;
- existence of factors that ‘push’ participants to engage;
- personal contact as part of the program;
- advantages/disadvantages to completing or using the program perceived by the participants;
- external events;
- usability issues;
- whether participants paid to access the program;
- the time commitment required;
- whether social support is available and participants’ participation in other programs/treatments.

The likely influence of these factors for the commercial program investigated is outlined in Table 9.1. It must be noted that the low drop-out attrition rates described are most likely due to participants being unable to unsubscribe from the program unless they had special circumstances (e.g. pregnancy, financial difficulties) preventing them from completing their subscription. Despite this, the large number of factors that potentially positively or negatively influenced drop-out and/or non-usage attrition makes it difficult to establish precisely how or why the patterns of attrition occurred. Therefore, to better understand the website use and prevalence of attrition demonstrated, further qualitative and quantitative research is required, investigating participant's reasons for website use, drop-out and/or non-usage, as well as the program-related and other external factors that may have influenced attrition.

Regardless of the reasons for poor website use and attrition rates, it is clear that improvement is required. Several of the suggested amendments to the commercial web-based weight loss program to improve weight-related outcomes (Section 9.2.1), may also boost utilisation rates. This includes the use of prompts (e.g. via email or text message) to participants to remind them to log-in and use specific program features, as well as the addition of strategies to ensure the program is customised to the individual, such as participant screening, access to personalised educational materials and feedback, and/or online counselling. Given the self-directed nature of the program, the most obvious current gap to address would be the development and provision of evidence-based guidelines outlining the website use required to achieve significant weight-related outcomes. The study findings outlining the median use of each website feature by percentage weight change group could be used for this purpose (Chapter Five). For example, the results presented here indicate that to achieve a weight loss of ≥10% after a 12-week subscription, you need to log-in to the website 34 days overall (~3 days/week), and also use the online diary 25 days overall (~2 days/week). To achieve a weight loss of ≥10% after a 52-week subscription, you need to log-in to the website 81 days overall (~2 days/week), and use the online diary 52 days overall (~1 day/week). However, given the decline in website use over time, it is likely that the level of use required to achieve success, is actually variable over time and stage of weight loss (e.g. initial weight loss or maintenance). For example, it may require greater initial usage (e.g. 3 to 4 days a week), then ongoing consistent use (e.g. 1 to 2 days per week). Therefore, future research should comprehensively evaluate usage at different stages of the program, and its relationship with weight loss over time, as well as the impact of adding the suggested website features on drop-out, non-usage attrition and weight-related outcomes.

Table 9.1 Factors potentially influencing website use and attrition rates for the commercial web-based weight loss program

Factor	Potential impact on attrition
Amount and suitability of information provided prior to enrolment	May not affect as participants provided with information (e.g. virtual tour) prior to enrolment. However, not compulsory to view, therefore cannot guarantee all enrolees aware of program specifics, and therefore these participant may be at greater risk of drop-out/non-usage. The information may not meet the needs of all participants.
'Right' users enrol	Age and BMI are the only eligibility criteria for enrolment. But as demonstrated demographic (age, gender, socio-economic status) as well as eating habits (e.g. eating breakfast, reasons for eating) and physical activity impact drop-out and non-usage attrition.
Too easy to drop-out or stop using	Difficult for participants to drop-out unless have special circumstance. However, easy to stop using, particularly after 12-weeks, when no reminders are sent.
"Push" factors	Participants sent weekly reminders to weigh-in during initial 12-weeks only. Therefore, lack of push factors may have enhanced non-usage and drop-out after this time.
Personal contact	Personal contact available through customer support, which is normally contacted for technical difficulties. Therefore, unlikely to drastically improve attrition. Contact with other members available through discussion forum. May improve attrition among participants who engaged, but use of the forums is low.
Advantages/ disadvantages to completing/using the program.	Most likely to be individual issues, therefore program itself does not currently influence.
External events	Most likely to be individual issues, therefore program itself does not currently influence. There may also be widespread events that positively or negatively influence attrition. For example the global financial crisis may have stopped participants signing up for longer. Program marketing (e.g. through the Biggest Loser television program) or other health promotion campaigns may positively influence attrition.
Payment	All participants paid for subscription. Some participants paid up front, others on a monthly basis. Therefore the impact on attrition could be variable.
Time commitment	The program is self-directed so participants can choose to use as much as the like. This could have a positive or negative impact on non-usage.
Other competing programs	Participants who completed the 15-month follow-up survey reported high prevalence of use of other weight loss programs, and the prevalence was higher in participants who subscribed to the web-based program for less time. Therefore, this may have impacted attrition.
Social support	Social support via the online discussion forum may have improved attrition. However, not all participants engaged with the program feature (12% of 12-week subscribers and 40% of 52-week subscribers)
Usability issues	Influence unclear, but potential to negatively impact usage if a usability a problem for participants.

9.2.3 Reach of web-based interventions to treat overweight and obesity

In order to improve the effectiveness and dissemination of web-based weight management interventions we require further understanding of the type of individuals

who participate, as well as who is most likely to complete treatment, engage with the website and achieve weight loss and/or weight loss maintenance.

In Chapter Four, the characteristics of participants who enrolled in a commercial web-based weight loss program were described, and the reach of the program was assessed using the RE-AIM framework (111). As hypothesised, participants who enrolled were similar to other commercial and web-based weight management program participants, i.e. predominantly female and of higher socio-economic status. However, the commercial program evaluated demonstrated appeal to younger adults and males, as there were a high proportion of participants aged 25 to 44 years, as well as male participants relative to other weight loss programs. The male enrolees were also at greater risk of obesity-related morbidities than the female enrolees, as they were more likely to be obese, and report poorer eating and activity habits at enrolment. The results also demonstrate that the commercial web-based weight loss program was unable to reach a large number of individuals of lower socio-economic status and/or from rural and remote areas, despite previous suggestions that this was a potential benefit of web-based interventions. However, the results do suggest that obese individuals in these target sub-groups are more likely to enrol.

The target group for the commercial web-based weight loss program was Australian adults aged 18 to 75 years who were trying to lose weight or prevent weight gain, and who had access to the Internet. The participants also had to be willing to pay the program's subscription fees. Approximately 1.6% of the potential target group enrolled in the program (2% females and 0.6% males). The highest participation rate was among obese 25 to 35 year olds, and for each gender. Therefore, the results demonstrate that the commercial web-based weight loss program has the potential to reach a large number of individuals, at high risk of weight-related morbidity and mortality, as highlighted by their high baseline BMI and poor eating and exercise habits.

There is also potential to predict at enrolment the participants who are at risk of drop-out and non-usage attrition (Chapter Six and Appendix 3). Participants' demographic (e.g. gender, age, socio-economic status) as well as behavioural characteristics (e.g. eating habits, exercise level and reasons for eating) predicted drop-out and/or non-usage attrition among 12- and 52-week subscribers. Like other weight loss and web-based interventions the individuals most in need of treatment were less likely to complete and/or engage with the treatment. For example, participants with poorer eating habits (e.g. did not eat breakfast, used butter in cooking, skipped meals) and lower levels of physical activity were at increased risk of drop-out and non-usage

attrition. Age also predicted attrition, with 52-week subscribers aged 35 to 65 years less likely to drop-out, and 12-week subscribers aged 45 to 65 years less likely to stop using the program. Furthermore, females and those of moderate-to-high socio-economic status were at increased risk of drop-out.

Therefore, it is possible that the groups of individuals identified as being 'at-risk' of drop-out or non-usage attrition may require different or extra strategies/features to promote their ongoing use of the web-based program. Alternatively, these individuals may be better suited to other treatment mediums. As outlined in Figure 9.1, participants at risk of drop-out or non-usage attrition could be identified at enrolment, and be prompted to select or automatically receive some of the additional features designed to improve attrition rates (e.g. the use of reminders to remind participants to log-in and use specific program features, access to personalised educational materials and feedback, and/or online counselling) and/or offered alternative treatment. The efficacy of such an approach has not been investigated and therefore needs to be tested in future research. The additional support required by 'at risk' participants may also vary. For example, younger adults may have higher expectations, given their high levels of internet use, so more innovative strategies to engage these participants may be required (e.g. combination of individualised communication with reminders and incentives (185)).

Chapter Six outlined the behavioural factors associated with successful weight loss (≥5%) 15-months post-enrolment in a commercial web-based weight loss program. Participants were more likely to be successful if they:

- weighed themselves at least once per month;
- did not skip meals or keep snack foods in the house or consume take-away foods more than once per week;
- were less likely to eat for emotional reasons;
- had higher levels of dietary restraint.

Therefore, the results support several of the behavioural factors identified in large cohort studies (e.g. self-monitoring of weight, physical activity levels, take-away food consumed, emotional eating and dietary restraint), such as the NWCR, as well as propose new behavioural factors associated with successful weight loss (i.e. not keeping snack foods in the house and /or not skipping meals). The results provide insight into the behavioural characteristics required to achieve significant weight loss, which should be targeted throughout the intervention. The behavioural factors associated with success could be emphasised from enrolment in the program, within

the program changes outlined in Figure 9.1. This could include identification of problem behaviours as part of pre-treatment screening, setting behaviour change goals related to these, providing participants with specific program features/ information/recommendations based on their 'at-risk' behaviours, and continuing to re-assess the behaviours throughout the intervention (e.g. as part of individualised feedback to the participants).

9.2.4 Assessing dietary intake via the Internet

Web-based weight management interventions provide an innovative way for participants to self-monitor their dietary intake, and also for researchers to assess participants' dietary intake. The systematic review presented in Chapter Three highlighted that most web-based weight management interventions offer web-based self-monitoring tools, most of which provided a web-based food diary (25, 36-40, 43, 46, 47, 51). However, the accuracy of dietary intake reported via web-based food diaries is not known. Therefore, the body of research in this thesis also evaluated how accurately a web-based food diary estimated EI in overweight and obese women (Chapter Eight).

The study found, in comparison to the gold standard DLW technique, overweight and obese women under-reported their EI by approximately 20% when using a web-based food diary, and that under-reporting of EI was common. Importantly, this level of accuracy is consistent with other types of food diaries (e.g. paper-based or PDA), which are typically underreported within the range of 4% to 47% (178). Therefore, web-based food diaries may offer an alternative approach for assessing as well as self-monitoring dietary intake. This is particularly important, as web-based food diaries offer a number of benefits, such as their ease of completion, that could address many of the inherent limitations of paper-based diaries, particularly high participant burden (130). There is also scope to improve the overall accuracy of the web-based food diary investigated. The diary evaluated was developed for intervention purposes, and therefore, other than a brief training session, did not provide any of the strategies typically used to improve accuracy (e.g. detailed initial instructions, reminder phone calls, user guides, and clarification of entries). Furthermore, strategies to overcome the limitations of web-based food diaries (e.g. not being completed at the time of food consumption) such as, completing the diary using a mobile/cell phone with Internet access, may also improve accuracy.

The findings also have important implications for users and providers of web-based weight management programs, such as the program investigated in this thesis. On

average, participants underreported EI by 550 calories per day. In order to accomplish a weight loss of 0.5 to 1 kg per week, participants aim to achieve a calorie deficit of at least 500 calories per day. Therefore, underreporting of EI as part of the self-monitoring process, may lead to unintentional overeating above the prescribed calorie target, and may result in failure to meet weight loss goals. Users of web-based weight management programs should be made aware that individuals typically misreport their EI, and educated on how to overcome this barrier (e.g. measuring quantities of food in the short term to become aware of typical portion sizes). Service providers may wish to incorporate appropriate educational materials as part of their program to help overcome misreporting. Alternatively, service providers could adjust for participants misreporting when setting EI targets. However, an improved understanding of the accuracy of reporting by different population groups (e.g. males, morbidly obese) is required, before such a system can be implemented.

9.2.5 Hypotheses

In summary, the research findings lead to the following assessment of the pre-defined hypotheses.

1. Participants who enrol in a commercial web-based weight loss program will be similar to other commercial and web-based weight management programs (i.e. predominantly female, middle-aged, higher socio-economic status).

The study findings support part of this hypothesis. Most participants were female and of higher socio-economic status. However, a higher proportion of males, and young-to mid-age adults (25 to 44 years) enrolled relative to other weight management programs.

2. Participants will achieve a mean weight change similar to the weight loss reported by systematic reviews of behavioural interventions (~5% to10%) during their 12- and 52-week subscription to the commercial web-based weight loss program.

The study findings were unable to support or reject this hypothesis. The mean weight change by 12-week subscribers is likely to be in the range of -3.0 to -6.2%, and 52-weeks subscribers within the range of -3.5 to -6.9%. While the results are suggestive, they may or may not be within the hypothesised range of 5% to 10% weight loss, and must be confirmed prospectively and objectively.

3. Participants' use of the commercial web-based weight loss program features will decline from baseline to 52-weeks.

The study findings support this hypothesis. Participants overall use of the program was greatest during the initial weeks. From the third subscription week the number of participants who used the website declined consistently for both 12- and 52-week subscribers. The number of participants who stopped using the website increased during the final weeks of participant subscriptions.

4. Greater use of the web-based weight management program will be associated with greater weight loss.

The study findings support this hypothesis. Significant correlations between the frequency of use of each website feature (log-ins, food and exercise diary entries, and forum posts) and percentage weight change were demonstrated. The median number of days each website feature was used also increased significantly as percentage weight change category improved.

5. Pre-treatment characteristics will predict drop-out and non-usage attrition in a commercial web-based weight loss program after 12- and 52-weeks membership.

The study findings support this hypothesis. The research demonstrated that both demographic and behavioural factors at enrolment predicted drop-out and non-usage attrition among 12- and 52-weeks subscribers.

6. Participants mean weight change will be lower (<5%) at 15-months post-enrolment in the commercial web-based weight loss program, due to weight regain following the completion of the intervention.

The study findings support this hypothesis. The research demonstrated that the median percentage weight change was -2.7% at 15-months post-enrolment which is lower than results after 12- and 52-weeks (-3% to -6.9%). However, given the group of participants who completed the 15-month follow-up survey are not representative of the full cohort, the results must be confirmed prospectively and objectively.

7. Successful weight loss (≥5%) at 15-months post-enrolment will be associated with self-monitoring of weight, food, and physical activity, as well as positive eating and physical activity habits.

The study findings do not completely support this hypothesis. Self-monitoring of weight, and some positive eating habits (e.g. not skipping meals or keeping snack foods in the house) were associated with successful weight loss. However, there was no association between successful weight loss and self-monitoring of food or physical activity, as well as a number of positive eating behaviours (e.g. eating breakfast,

alcohol consumed in moderation), or physical activity habits (e.g. low levels of sedentary behaviour)

8. Participants will under-report their energy intake using a web-based food diary to the within the range of other food diaries (4% to 47%)

The study findings support this hypothesis. The study found that, on average, participants unreported their EI by an average of 20%.

9.3 Research strengths and limitations

Specific strengths and limitations related to the individual research aims, and overall study design were addressed in the published papers presented in the preceding chapters. However, there are important overall strengths and limitations of the body of research that are collectively outlined below.

9.3.1 Systematic review

Strengths

The systematic review enhanced the evidence base in the area of web-based weight management, for several reasons. Firstly, a thorough and up-to-date literature review captured additional studies not included in previous reviews. Secondly, the review was conducted using a standardised systematic review methodology to ensure a systematic and high quality approach. For the first time an effect size for different types of web-based weight management interventions were estimated through meta-analyses. Finally, the results were reported as per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (186).

Limitations

The primary limitation of the review is that it was completed in 2008 and accepted for publication in 2009. Therefore, at least six relevant RCTs (53, 55-58) have been published since the completion of the systematic review, which may influence the results. Given the growing research interest in the area of web-based weight management, there is a need for ongoing (e.g. bi- or tri-annual) updates of the review.

9.3.2 Cohort study

Strengths

The cohort study, which tracked participants of a commercial web-based weight loss program, is novel for many reasons. It was the first cohort study of usual or ‘real world’

participants of a commercial web-based program and the first *commercial* and *web-based* weight loss program study to occur in Australia, and the only *web-based weight loss program* study conducted in Australia including both males and females. The large sample size (>11,000) also adds strength to the study, by improving precision of the outcomes, and allowing strongly powered analyses. Use of a sample of usual participants of the program, also eliminates sampling bias, as the population is representative of all participants who enrolled in the program. Therefore, the research makes an important contribution to the field of obesity treatment research.

Allowing for the study design, the cohort study also assessed weight change in a valid and sensitive way. Unlike many other studies of web-based and commercial weight loss program, the analysis included all participants who enrolled in the program. This was achieved through an intention-to-treat approach to the analysis of weight change after 12- and 52-week subscriptions, as well as a sensitivity analysis to assess the robustness of the GLMM used for the intention-to-treat analysis.

The cohort study also addressed important research questions pertaining to the effectiveness of web-based interventions previously highlighted as key areas for further research. This included assessment of the reach of the program, as well as the prevalence and predictors of website use. Reach and website use were assessed using methods recommended by experts in the field of web-based public health interventions, namely the RE-AIM framework (111), and drop-out and non-usage attrition (89). Data on website use was also collected using objective measures. Therefore, the study not only makes an important contribution to the field of obesity treatment, but also has potential implications for all health-related interventions delivered by the Internet.

Limitations

Limitations of the cohort study include that the study design does not allow assessment of cause-and-effect. This means that we cannot conclude that changes in weight or other behaviours were achieved due to participation in the program. There are also many confounding factors that may have influenced the study participants, and therefore the results (e.g. participation in other weight loss programs, sickness, smoking etc.).

The cohort study also relies on self-reported data (i.e. pre-treatment characteristics and weight), which may have introduced measurement bias. Reliance on self-reported data, particularly for weekly weigh-ins resulted in missing data. However, the approach to the statistical analysis (GLMM) ensured the missing data was considered in an appropriate

manner, therefore reducing the bias the missing data could have introduced. Furthermore, the sensitivity analysis using the LOCF approach tested the robustness of the GLMM, to evaluate the potential impact of the missing data on the results, the results of the LOCF were taken into consideration when interpreting the results and the final overall results were reported as a range.

Although the stated aim of this thesis was to explore the potential of the commercial web-based weight loss program as a treatment option for overweight and obese adults, the cohort study included some healthy weight individuals (BMI≥22 to 25). This is because the commercial web-based weight loss program allows participants to enrol in the program with a BMI down to 22, with the aim of preventing weight. These participants were included in the study to ensure the sample was representative of all participants who enrolled in the program. Therefore, the results are not entirely specific to overweight and obese individuals.

Notably, the publication presented in Chapter Six did not report the pre-treatment predictors of drop-out attrition, which were instead presented as an appendix. Participants required special circumstances (e.g. pregnancy or financial difficulties) to end their membership to the program. Therefore, the drop-out attrition rates accurately portray drop-out in the context of this program, but do not include those participants who may have wanted to end their subscription (e.g. due to weight loss difficulty or problems with the program) but were unable to, due to the program's policy for not allowing subscriptions to be ceased for these reasons. The predictors of drop-out attrition (Appendix 3) should therefore be interpreted with this limitation in mind. Further research is required to accurately evaluate the prevalence and predictors of drop-out attrition for commercial web-based weight loss programs.

The study also did not track the use of all features of the web-based program (e.g. whether participants viewed weekly tutorials, menu or exercise plans, or forum posts), as this data was not available at the time of the study. Therefore, our understanding of the use of the web-based program is incomplete, and may have overestimated non-usage attrition rates. This limitation should be addressed in any further observational or experimental research undertaken to evaluate the program.

Finally, the body of research also does not investigate a vital component of an 'effective' weight management program, i.e. cost-effectiveness. Although the research alludes to the potential cost-effectiveness of the program investigated, the true cost-effectiveness of the program is not established, and should be investigated in future studies.

9.3.3 Long-term follow-up study

Strengths

This study is novel, as it is one of the first studies to investigate the long-term weight loss achieved by actual participants of a commercial web-based weight loss program, and one of only a handful to evaluate this for any type of commercial weight loss program (122, 124-126). Furthermore, unlike the other studies it did not only include a selective group of participants, such as those who were successful at achieving weight loss during the intervention. Instead, the eligibility criteria for the study included all participants who enrolled, and were willing to be contacted for research purposes, therefore improving the external validity of the results.

Limitations

The attempt to maximise the external validity of the follow-up survey results, through recruitment of participants who were representative of all individuals who participate in a commercial web-based weight loss program, was not entirely successful. There were significant differences in some characteristics of participants who completed the online survey and the full cohort. The response rate for the survey was also low, although comparable to a similar surveys that followed-up participants' 12-months post-enrolment in an online weight loss program (173). Therefore, the results may not represent the true prevalence of successful weight loss 15-months post-enrolment in a commercial web-based weight loss program. Furthermore, like the cohort study, the long-term follow-up survey relied on self-reported data which may have introduced measurement bias. However, to reduce these bias validated questionnaires were used where possible.

9.3.4 Validation sub-study

Strengths

The validation study makes an important and original contribution to the assessment of dietary intake, particularly given the need for new and innovative approaches for assessment. It is the first study to evaluate the accuracy of EI self-reported using a web-based food diary. It also utilised the gold standard DLW technique.

Limitations

The main limitation of the study is the small and homogenous sample. The results may not be applicable to other population groups and may overestimate the occurrence and magnitude of misreporting, as the sample, overweight and obese females, are prevalent under-reporters.

9.4 Implications of the body of research

9.4.1 For practice

The implications of this body of research for practice are three-fold, and relate to overweight and obese individuals, clinicians and web-based weight management program developers/service providers.

The body of research suggests, given their appeal and potential to achieve significant weight loss, treatment seeking overweight and obese individuals should consider the use of web-based weight management interventions. Clinicians, such as general practitioners and dietitians, need to be aware of the potential and benefits of this mode of treatment and could consider recommending web-based weight management programs to their overweight and obese clients. This may be a way to cope with the high demand for treatment by overweight and obese clients, and to target groups to whom the program appeals. Clinicians could recommend web-based weight management interventions as the sole source of treatment or as an adjunct to other modes of delivery including group or one-on-one consultations.

Currently, few of the web-based weight management programs that have been scientifically evaluated are available to consumers; therefore clinicians are restricted in the programs that they can recommend to clients, and overweight and obese individuals the programs they can select. The findings from this research suggest that commercial web-based weight loss programs may offer a readily available alternative to programs developed by health or university departments. However, clinicians and overweight and obese individuals must ensure the commercial providers present evidence to support their claims of effectiveness, through dissemination of research findings, published via peer-reviewed processes.

Clinicians should also be aware that web-based weight management programs may offer more appeal to specific individuals, and therefore recommend accordingly. Service providers may also wish to target their programs to these individuals. The study findings specifically suggest young-to-mid age females are most interested in the treatment medium. The findings also highlight that males may be more interested in a web-based program than a more traditional approach such as face-to-face group sessions, and that obese individuals in rural and remote areas may also be attracted to the treatment medium.

Clinicians and service providers must also consider that particular individuals may be more likely to use and complete web-based weight loss programs, namely older

participants (aged 45 to 65 years) and those with positive eating and physical activity habits at enrolment. This suggests that other individuals (younger participants with poor eating and physical activity habits) may require additional support to engage with web-based treatments, or alternatively that they may be better suited to alternative treatment options. Clinicians and service providers should consider comprehensive pre-treatment screening of potential participants of web-based weight management programs, to identify individuals who are best suited to the treatment medium and identify who may be 'at risk' of drop-out and non-usage attrition. They can then provide additional web-based features (Figure 9.1) and/or alternative treatment options (e.g. face-to-face sessions) to those 'at-risk' of attrition.

The research findings also suggest that in order to maximise their chance of success (i.e. achieve a weight loss of at least 10% of their initial weight) clinicians should recommend that their clients consistently use the web-based program. Participants may need to log-in 2 to 3 days per week and use the online diary 1 to 2 days per week. Longer intervention length (i.e. 12-months) may also be required to achieve and maintain weight loss.

Overweight and obese individuals should also consider selecting web-based programs that include a food and activity diary for self-monitoring. Clinicians should also recommend programs with such diaries, while program developers should consider incorporating online diary into their product. This is because self-monitoring of dietary intake and physical activity are key components of behavioural and web-based weight management programs, and use of online diaries was positively associated with weight loss in this study. However, the potential for under-reporting of EI when using the diary, especially if using the diary to evaluate intake against a prescribed calorie target, must be considered by individuals when using the diary, clinicians when counselling clients and service providers when developing their program.

The body of research also suggests that although modest weight loss can be achieved through use of a self-directed low intensity web-based weight loss program, there is scope for program developers to add additional web-based program features (e.g. individualised feedback, counselling) in an effort to further improve weight-related outcomes, and also boost utilisation and completion rates (Figure 9.1). However, program developers must ensure that the cost of providing any additional features does not outweigh the benefits. Program developers and clinicians should also ensure key behavioural changes are promoted to participants to increase their probability of success. This includes self-monitoring their weight (more than once per month), not

skipping meals or keeping snack foods in the house, limiting takeaway foods to less than once per week, avoiding emotional eating, and demonstrate dietary restraint.

9.4.2 For research

This body of research provides recommendations for future research to confirm the efficacy and further investigate the commercial web-based weight loss program evaluated, as well as key recommendations for researchers currently evaluating web-based weight management interventions.

Firstly, the results from the cohort and long-term follow-up study are promising, but must be confirmed prospectively and objectively. This should include a RCT to investigate the efficacy of the commercial web-based weight loss program in achieving weight loss and weight loss maintenance. The RCT should comprehensively and objectively assess the impact of the intervention on weight and other clinically important weight-related outcomes (e.g. blood sample biomarkers, blood pressure) in both the short- and long-term, as well as cost-effectiveness. The RCT could also test the ability of some, or all of the intervention strategies suggested to improve retention, user engagement and weight loss outcomes, and whether the impact is differential across population sub-groups. It should also further test the hypotheses raised regarding the association between website use and weight loss outcomes, as well as pre-treatment predictors of attrition. Collection of more objective website use data to embody all features of the web-based program would further improve the study. Results from the body of research have already been used to inform the design of an RCT currently in progress to test the efficacy of the commercial web-based program in the format presented in this thesis, and a newly designed 'enhanced' web-based program (187). This includes the development of a specific program for weight loss maintenance.

In addition, further observational research involving actual program participants will enhance understanding of the nature of participants' engagement with web-based programs, and resultant outcomes over time. This could include further analysis and follow-up of the existing cohort study data (e.g. exploring patterns of website use and its association with weight loss). Alternatively, a prospective cohort study could be undertaken with usual participants of commercial web-based weight loss programs. Such a study design could overcome some of the limitations of the current cohort study. For example, weight could be objectively measured in all, or a subset of participants to reduce measurement bias. Furthermore, the prospective design would

allow greater exploration of participants' reasons for drop-out and non-usage attrition, at the time of occurrence, using both quantitative and qualitative methodologies.

Further investigation of web-based food diaries is also required to confirm their validity. This includes further assessment of the accuracy of the diary in more diverse population groups (e.g. males) and for other nutrients. The web-based diary should also be directly compared to other diary formats (e.g. paper-based) in relation to its accuracy, as well as other factors associated with dietary assessment tool suitability (e.g. respondent burden). Additional strategies to improve accuracy and completion (e.g. user guides, reminder phone calls), as well overcome the limitations of using the Internet (e.g. mobile/cell phones) should also be tested.

The increasing research activity in the area of web-based weight management, even in the short time frame in which this thesis was undertaken (2008 to 2011), highlights the need for the systematic review presented in Chapter Three to be updated bi- or tri-annually. There is scope for the systematic review to more thoroughly assess the effectiveness of web-based weight loss and weight loss maintenance interventions given the increased research activity, as well as the publication of additional research assessing such factors as cost-effectiveness (e.g. (188, 189)) and behaviour change (e.g. (190)).

To substantiate the effectiveness of web-based weight management interventions, as well as assist with the ongoing update of the systematic review, it is recommended that researchers consider conducting well-designed efficacy trials that adhere to the CONSORT guidelines. The RCTs should compare web-based interventions with the traditional methods of delivering lifestyle interventions (e.g. individual and group-based counselling) or to waiting list controls, and assess weight loss and maintenance of lost weight in the long-term. They should also consider designing studies to determine which components of web-based interventions are critical to achieving efficacious outcomes, including determination of an optimal usage, as well as strategies to improve attrition rates and website use. Researchers must also therefore begin reporting results for website use in a consistent and comparable manner, using such metrics as non-usage attrition or proportion of possible or expected days each website feature was used.

9.5 Concluding remarks

In their currently available form, web-based weight management interventions provide an alternate treatment medium for overweight and obese individuals, which may only

be suited to specific population groups. However, with the exponential growth in Internet access, as well as in its use as part of daily life, web-based interventions provide an innovative and timely treatment option for the growing numbers of treatment seeking individuals now and into the future. Researchers, clinicians and developers of web-based programs must work together to continue to develop, evaluate, refine and disseminate effective web-based weight management programs. There is a need to further establish the effectiveness and value of web-based weight management programs, not only in relation to their ability to achieve clinically important weight outcomes, but also in terms of their reach and potential cost-effectiveness. However, there are several key challenges to face that should be the focus of current and ongoing work. Firstly, the development of programs incorporating key elements of evidence-based behavioural weight management interventions, while concurrently embracing and keeping up-to-date with the capabilities of the Internet. Secondly, improving users' experience and engagement with the web-based programs in the long-term, especially for those groups identified as 'at-risk' of poor engagement. Thirdly and finally, improving long-term weight loss outcomes and further exploring the use of the Internet to capture valid and reliable data, including dietary intake data.

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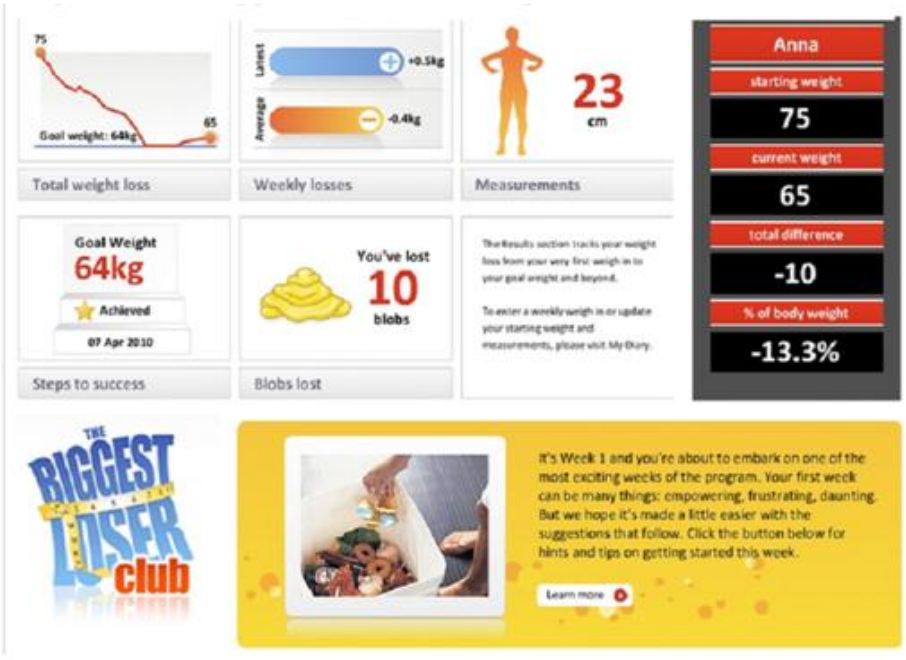
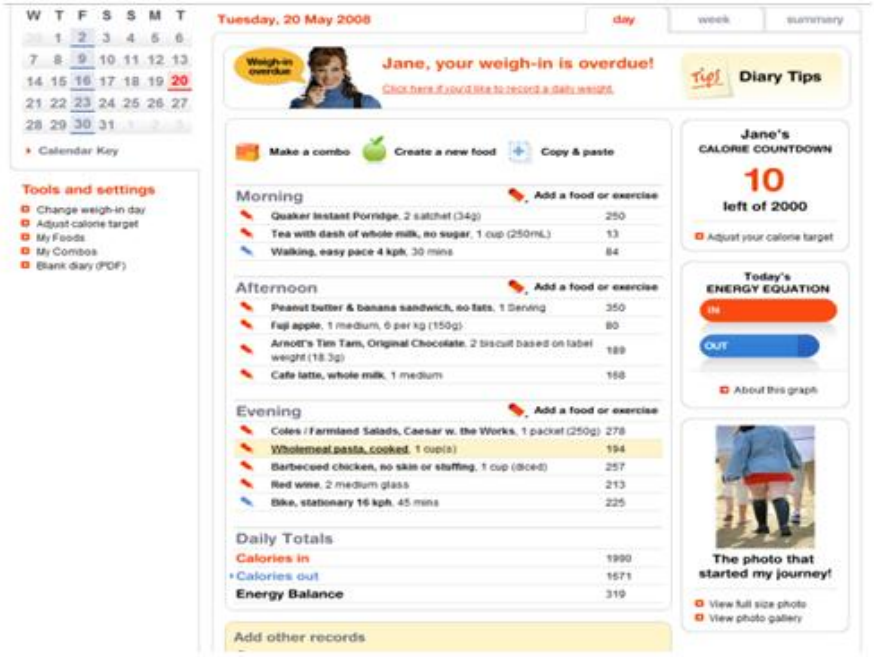
Appendices

Appendix One: The Biggest Loser Club program features

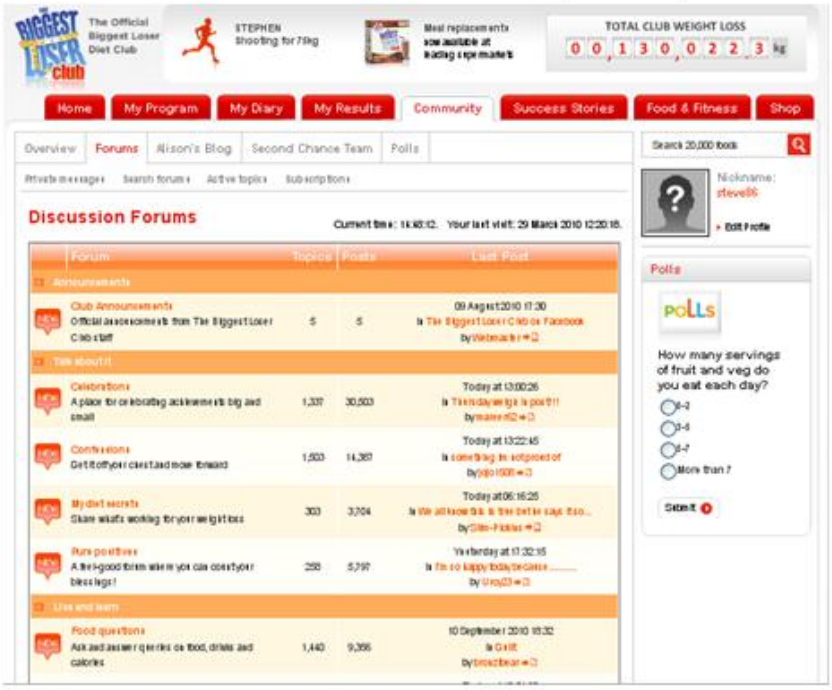
Homepage



Weigh-in page



Online food and activity diary



Discussion forum

Appendix Two: Pre-treatment survey

Step 1. Confirm your starting point

Starting weight and height

Weight _____ kg

Height _____ m

Your body measurements (optional)

Waist _____ cm

Hips _____ cm

Thighs _____ cm

Arms _____ cm

Chest _____ cm

Your ethnicity (optional)

- ☐ I prefer not to say
- ☐ Aboriginal/Torres Strait Islander
- ☐ Anglo-Saxon (British/Irish/Scottish descent)
- ☐ Asian
- ☐ Eastern European
- ☐ European
- ☐ Indian
- ☐ Maori
- ☐ Middle Easterner
- ☐ Polynesian

Step 2. How active are you?

How active are you?

Which of the following best describes your everyday activity level:

- ☐ Sedentary or immobile- in a wheelchair or seated all day
- ☐ Office worker or house keeper- seated for extended periods throughout the day
- ☐ Active and on-the-go – on your feet for extended periods throughout the day e.g. building inspector, child care worker, handyman, hospitality.
- ☐ Manual labourer – doing hard physical work most of the day

Current exercise level

How many days a week are you currently doing planned exercise e.g. brisk walking, going to the gym?

- ☐ 0 – 1 days a week

- 2 – 3 days a week
- 4 – 5+ days a week

What type of exercise program would you prefer?

- A walking program
- A gym program
- A low-impact program (good for people with joint discomfort)
- Combo gym and walking program

Step 3 Please tell us a bit about your diet

Menu plan preferences

What sort of menu plan would you like?

- Basic menu: Includes limited ingredients and very simple meals. Best choice for members in rural areas.
- Variety menu: Lots of delicious meal ideas. Best choice for members who like to cook.
- Vegetarian menu: Suitable for lacto-ovo vegetarians. Lactovegetarians can simply omit the eggs.

Vegetable intake (optional)

How often do you eat fresh vegetables?

- Several times a day
- A few times a day
- On most days
- On some days
- Hardly ever

Cooking and eating habits (optional)

- Do you do any of the following? Tick any that apply.
- Fry foods
- Use butter in cooking
- Drink full sugar soft drinks
- Skip meals
- Drink tea or coffee with sugar
- Eat breakfast
- Use low-fat products wherever possible
- Keep snack foods in the house (e.g. chips, lollies)

□ Drink 6+ glasses of water a day

Eating behaviour (optional)

Do you eat for any of these reasons? Tick all that apply

□ To ease emotional upsets

□ For the joy of it

□ To reduce stress

□ Out of boredom

Temptations (optional)

Do you have any food, which you find hard to control yourself with e.g. chocolate biscuits, fried chicken? _____

Step 4. When would you prefer to weigh in?

Weigh-in Day

Which is your preferred weigh-in day?

Please note that your first weigh-in will be a minimum of 7 days from today.

□ Monday

□ Tuesday

□ Wednesday

□ Thursday

□ Friday

□ Saturday

□ Sunday

SMS Weigh-ins

Would you like to weigh-in by SMS? (for the cost of a regular text message)?

□ Yes

□ No

Mobile Number _____

Step 5. What are your goals?

Your goal weight

According to World Health Organization Guidelines, your healthy range is

We typically recommend you set your goal weight within this range, however, this may vary depending on your gender, physique and ethnicity.

Do you have a goal weight in mind?

□ Yes, I know what weight I want to be.

□ No, I'd prefer the Club to recommend a goal for me

Goal weight

Your reasons for losing weight

It helps to record why you setting out on this journey, in case you ever need a reminder down the track.

Why I am losing weight (optional)

□ To look good

□ To feel good

□ For me

□ For my kids

□ For my health

□ For my future (I'm not ready to die just yet)

□ For my career

□ For my wedding

□ For my love life

□ Because my doctor advised it

□ Because I'm embarrassed about my size

□ Because a love one recommended it

□ Because of a health scare

□ Because I lost someone close to me

□ To get my pre-baby body back

Step 6. A little more about you

Street address

Suburb

State

Postcode

Either a daytime or mobile phone number is required

Daytime phone

Mobile phone

Health conditions (optional)

Please list any of the following health conditions that affect you

□ Asthma

- Heart disease
- High blood pressure
- High cholesterol
- Hypertension
- Kidney problems
- Liver disease
- Sleep apnoea
- Type 1 Diabetes
- Type 2 Diabetes

Research studies (optional)

Are you interested in participating in any research studies or surveys conducted by the Club?

- Yes
- No

Appendix Three: Pre-treatment predictors of drop-out attrition

Aim

To describe pre-treatment predictors of dropout and nonusage attrition in a commercial web-based weight loss program after 12- and 52-weeks membership

Method

The participants and design, intervention, data collection and pre-treatment characteristics are as outlined in Chapter 6.

Drop-out attrition

The date a participant enrolled in commercial web-based weight loss program and the date membership ceased were used to calculate the number of days each participant was a member of the program (duration of membership). The date membership ceased was the end date of their subscription plan, unless the participant had special circumstances that prevented them from completing their subscription (e.g. pregnancy, financial constraints). Participants were classified as a member of program at 12- or 52-weeks if they held an active subscription plan at that time-point (i.e. membership days ≥78 days for 12-weeks and ≥359 days for 52-weeks). Otherwise they were classified as a drop-out.

Data analysis

Data analysis was undertaken using Stata 11 IC (StataCorp LP, College Station, USA). Participants' pre-treatment characteristics were investigated as predictors of drop-out attrition for 12- and 52- week subscribers using Cox Proportional Hazards regression analyses. The time variable was the duration of membership (days). Drop-out was considered as a failure in the respective models. Univariate analyses were conducted on all pre-treatment predictor variables of interest and those with $p<0.2$ were included in a stepwise regression analysis to find the most parsimonious model. The proportional hazards assumption was tested for each model using the Schoenfeld residuals. The significance level was set at $\alpha = .05$

Results

Predictors of drop-out attrition: 12-week subscribers

Table 1 describes predictors of drop-out attrition among 12-week subscribers from the univariate analysis. In the multiple regression analysis, two pre-treatment characteristics were found to significantly predict drop-out attrition. Those who reported eating breakfast at baseline had a significantly decreased risk of drop-out (HR 0.68 (0.51, 0.89) p=.005), while those who reported frying foods had a significantly increased risk of dropping out (HR 1.49 95%CI: 1.15, 1.95 p=.005).

Predictors of drop-out attrition: 52-week subscribers

Table 2 describes predictors of drop-out attrition among 52-week subscribers from the univariate analysis. In the multiple regression analysis, four pre-treatment characteristics were found to significantly increase a participants risk of dropping out by week 52, this included being female (*p*=.005), aged 65 to 75 years (*p*=.023) and having poor eating habits such as using butter in cooking (*p*=.03) or drinking tea or coffee with sugar (*p*=0.008). Five pre-treatment characteristics significantly decreased a participant's risk of drop-out. Participants aged 35 to 65 years (*p*<.001), of moderate (IRSAD 5-6) (*p*=.03) and high (IRSAD 9-10) (p=.006) socio-economic status, who exercised more than one day a week (*p*<.001), consumed food for the joy of it (*p*=.001), and ate breakfast (*p*<.001), had a significantly decreased risk of drop-out.

Table 1 Risk of drop-out attrition for 12- subscribers

Risk factor	Unadjusted n=6943		Adjusted n=6941	
	Hazard ratio (95% CI)	*p*	Hazard ratio (95% CI)	*p*
Gender				
Male	1.00 (ref)			
Female	0.76 (0.54,1.07)	.12		
Age				
18 to 25 years	1.00 (ref)			
25 to 35 years	0.98 (0.68,1.42)	.93		
35 to 45 years	0.72 (0.48,1.08)	.11		
45 to 55 years	0.50 (0.29,0.88)	.02		
55 to 65 years	0.77 (0.32,1.81)	.54		
65 to 75 years	1.02 (0.14,7.44)	.98		
Socio-economic status (IRSAD) [a]				
Decile 1-2	1.00 (ref)			
3-4	0.59 (0.32, 1.07)	.08		
5-6	0.61 (0.36, 1.03)	.07		
7-8	0.52 (0.31, 0.85)	.01		
9-10	0.49 (0.30, 0.80)	.005		
Remoteness[b]				
Major cities of Australia	1.00 (ref)			
Regional Australia	1.15 (0.85, 1.55)	.37		
Rural and remote Australia	1.70 (0.70, 4.14)	.24		
BMI				
Healthy Weight	1.00 (Ref)			
Overweight	1.12 (0.66, 1.91)	.67		
Obese	1.57 (0.95, 2.59)	.08		
Exercise level[c]				
0-1 days	1.00 (Ref)			
2-3 days	0.76 (0.57, 1.03)	.08		
4+ days	0.95 (0.67,1.35)	.77		
Reason for eating				
To ease emotional upset	1.02 (0.79, 1.32)	.87		
For the joy of it	0.76 (0.59, 0.98)	.03		
To reduce stress	0.84 (0.65, 1.09)	.18		
Out of boredom	1.14 (0.82, 1.58)	.43		
Eating habits				
Fry foods	1.57 (1.22, 2.03)	.001	1.49 (1.15, 1.95)	.005
Use butter in cooking	1.26 (0.97, 1.63)	.08		
Drink full sugar soft drinks	1.44 (1.11, 1.88)	.007		
Skip meals	1.47 (1.13, 1.91)	.004		
Drink tea or coffee with sugar	0.93 (0.72, 1.21)	.61		
Eat breakfast	0.64 (0.49, 0.84)	.001	0.68 (0.51, 0.89)	.005

Use low fat products	0.67 (0.52, 0.87)	.003
Keep snack foods in the house	1.20 (0.92, 1.57)	.17
Drink 6+ glasses of water a day	1.03 (0.80, 1.34)	.82
Reason for weight loss		
One or more health related reason	0.94 (0.73, 1.22)	.65

[a] n= 6839,[b] n=6 840, [c] n=6921.

Table 2. Risk of drop-out attrition for 52- subscribers

Risk factor	Unadjusted n=2656		Adjusted n=2604	
	Hazard ratio (95% CI)	*p*	Hazard ratio (95% CI)	*p*
Gender				
Male	1.00 (ref)		1.00 (ref)	
Female	1.42 (1.10,1.83)	.007	1.46 (1.12, 1.89)	.005
Age				
18 to 25 years	1.00 (ref)		1.00 (ref)	
25 to 35 years	0.83 (0.65, 1.05)	.09	0.82 (0.64, 1.05)	.11
35 to 45 years	0.59 (0.46,0.76)	<.001	0.63 (0.49, 0.81)	<.001
45 to 55 years	0.40 (0.29, 0.56)	<.001	0.45 (0.32, 0.64)	<.001
55 to 65 years	0.23 (0.12, 0.45)	<.001	0.29 (0.15, 0.58)	<.001
65 to 75 years	2.19 (0.6, 5.00)	.06	2.64 (1.15,6.08)	.02
Socio-economic status (IRSAD) [a]				
Decile 1-2	1.00 (ref)		1.00 (ref)	
3-4	0.99 (0.72,1.36)	.94	1.06 (0.77, 1.47)	.71
5-6	0.63 (0.46, 0.85)	.003	0.71 (0.53, 0.97)	.03
7-8	0.65 (0.49, 0.86)	.003	0.75 (0.56, 1.00)	.052
9-10	0.55 (0.51,0.83)	.001	0.67 (0.50, 0.89)	.006
Remoteness[b]				
Major cities of Australia	1.00 (ref)			
Regional Australia	1.08 (0.90,1.30)	.39		
Rural and remote Australia	2.14 (1.32, 3.47)	.002		
BMI				
Healthy Weight	1.00 (ref)			
Overweight	0.95 (0.68,1.55)	.84		
Obese	1.01 (0.64, 1.60)	.96		
Exercise level[c]				
0-1 days	1.00 (ref)		1.00 (ref)	
2-3 days	0.63 (0.52, 0.76)	<.001	0.67 (0.55, 0.82)	<.001
4+ days	0.49 (0.39, 0.63)	<.001	0.57 (0.44,0.74)	<.001
Reason for eating				
To ease emotional upset	1.02 (0.87, 1.20)	.78		
For the joy of it	0.76 (0.65, 0.89)	.001	0.77 (0.65, 0.90)	.001
To reduce stress	0.81 (0.68, 0.95)	.009		
Out of boredom	1.06 (0.87, 1.28)	.58		
Eating habits				
Fry foods	1.26 (1.07, 1.48)	.004		
Use butter in cooking	1.28 (1.09, 1.50)	.003	1.20 (1.02, 1.42)	.03
Drink full sugar soft drinks	1.32 (1.12, 1.56)	.001		
Skip meals	1.52 (1.28, 1.79)	<.001		
Drink tea or coffee with sugar	1.44 (1.23, 1.69)	<.001	1.25 (1.06, 1.47)	.008
Eat breakfast	0.61 (0.52, 0.72)	<.001	0.73 (0.61, 0.86)	<.001
Use low fat products	0.73 (0.62, 0.85)	<.001		
Keep snack foods in the house	1.04 (0.88, 1.23)	.61		
Drink 6+ glasses of water a day	0.86 (0.73, 1.02)	.08		
Reason for weight loss				
One or more health related reason	0.83 (0.71,0.98)	.03		

[a] n= 2614, [b] n= 2614 [c] n=2646

Appendix Four: 15-month follow-up survey

Welcome. Thank you for deciding to complete the survey

The following questions are about your experience with the Biggest Loser Club.'

1. Why did you decide not to continue your subscription with the Biggest Loser Club? Please select all that apply.

- ☐ I can't afford it
- ☐ I wasn't losing weight
- ☐ I wasn't using it
- ☐ I was happy to continue on my own
- ☐ I met my goal weight
- ☐ I wasn't motivated
- ☐ It wasn't for me
- ☐ I needed more personal support
- ☐ I had no support from family and/or friends
- ☐ I'm too busy
- ☐ I had poor access to the Internet
- ☐ My membership expired
- ☐ I went on holidays/trip overseas
- ☐ Other (please specify) _____

2. Overall, how satisfied were you with the service provided by the Biggest Loser Club?

- ☐ Extremely satisfied
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied
- ☐ Extremely dissatisfied

N.B. These questions were for participants who were not members of the program at time of survey completion.

1. Why have you continued your subscription with the Biggest Loser Club? Please select all that apply.

- ☐ The value for money
- ☐ I'm losing/maintaining my weight
- ☐ I have not met my goal weight
- ☐ To motivate me
- ☐ I like using the web-based program
- ☐ The support I get from the Club
- ☐ It is time efficient

- It is easy to access the Internet
- Other (please specify) _____

2. Overall, how satisfied are you with the service provided by the Biggest Loser Club?

- Extremely satisfied
- Satisfied
- Neutral
- Dissatisfied
- Extremely dissatisfied

N.B. These questions were for participants who were members of the program at time of survey completion.

The following questions are about weight and dieting

3. In the last 12 months, other than the Biggest Loser Club, have you used any of the following methods to control your weight or shape? Please mark all that apply

- Attended commercial face to face weight loss program (e.g. Weight Watchers, Jenny Craig).
- Used meal replacements or slimming products (e.g. Optifast, Tony Ferguson, Celebrity Slim.
- Fad diets (e.g. Atkins)
- Using dieting books or manuals (e.g. CSIRO Total Wellbeing)
- Used other web-based programs (e.g. CalorieKing, Weight Watchers)
- Used weight loss medications (e.g. Xenical, Reductil, Duromine)
- Had surgery to lose weight (e.g. gastric bypass, lapband)
- Visited a health professional to help you lose weight (e.g. dietitian, psychologist)
- None of the above

4. Currently how often do you do each of the following?

Weigh yourself	Several times a day	1 time/day	Several times/week	1 time/week	<1 time/week	< 1 time/month	Never
Record the type and/or amount of food and drinks you consume	Several times a day	1 time/day	Several times/week	1 time/week	<1 time/week	< 1 time/month	Never
Record the type and/or amount of exercise you do	Several times a day	1 time/day	Several times/week	1 time/week	<1 time/week	< 1 time/month	Never

5. How much do you currently weight? (in kilograms)

6. Since first joining the Biggest Loser Club about 15-months ago, what is the lowest weight you have been? (in kilograms)

7. Are you currently pregnant or have you been pregnant since joining the Biggest Loser Club?

- Yes
- No

The following questions are about eating

8. How many serves of vegetables do you usually eat each day? One serve is equal to ½ cup cooked or 1 cup of salad vegetables.

- I don't eat vegetables
- Less than 1 serve of vegetables per day
- 1 serve of vegetable per day
- 2 serves of vegetable per day
- 3 serves of vegetable per day
- 4 serves of vegetable per day
- 5 serves of vegetable per day
- 6 or more serves of vegetable per day

9. How often do you eat fresh vegetables?

- Several times a day
- A few times a day
- On most days
- On some days
- Hardly ever

10. Do you do any of the following? Please tick all that apply

- Fry foods
- Use butter in cooking
- Drink full sugar soft drinks
- Skip meals
- Drink tea or coffee with sugar
- Eat breakfast

- Use low fat products wherever possible
- Keep snack foods in the house (e.g. chips, lollies)
- Drink 6+ glasses of water a day
- None of the above

11. How many days per week do you usually have something to eat for breakfast?

- Rarely or never
- 1 to 2 days
- 3 to 4 days
- 5 or more days

12. Do you eat for any of these reasons?

- To ease emotional upset
- For the joy of it
- To reduce stress
- Out of boredom
- None of the above

13. How many serves of fruit do you usually eat each day? One serve is equal to 1 medium piece or 2 small pieces of fruit or 1 cup of diced pieces.

- I don't eat fruit
- Less than 1 serve of fruit/day
- 1 serve of fruit/day
- 2 serves of fruit/day
- 3 serves of fruit/day
- 4 or more serves of fruit per day

14. How many cups of soft drink, cordials or sports drink do you usually drink in a day, excluding diet or low joule drinks? One cup is equal to 250mL.

- I don't drink soft drink, cordials or sports drinks
- Less than 1 per day
- 1 per day
- 2 to 3 per day
- 4 to 6 per day
- 7 or more per day

15. How often do you have meals or snacks such as burgers, pizza, chicken or chips from take-away places?

□ I don’t have meals from take-away places

□ Less than once per month

□ 1 to 3 times per month

□ 1 time per week

□ 2 times per week

□ 3 to 4 times per week

□ 5 to 6 times per week

□ 1 time per day

□ 2 times per day

□ 3 or more times per day

16. How often do you have meals or snacks at a restaurant?

□ I don’t have meals from restaurants

□ Less than once per month

□ 1 to 3 times per month

□ 1 time per week

□ 2 times per week

□ 3 to 4 times per week

□ 5 to 6 times per week

□ 1 time per day

□ 2 times per day

□ 3 or more times per day

17. How often do you usually drink alcohol?

□ I never drink alcohol

□ Less than once per month

□ 1 to 3 times per month

□ 1 time per week

□ 2 times per week

□ 3 to 4 times per week

□ 5 to 6 times per week

□ Everyday

18. Alcoholic drinks are measured in terms of a standard drink. A standard drink is equal to one middy of full strength beer, one schooner of light beer, one small glass of wine, or one pub-sized nip of spirits. On a day when you drink alcohol, how many standard drinks do you usually have?

□ 1 to 2 drinks per day

□ 3 to 4 drinks per day

□ 5 to 8 drinks per day

□ 9 or more drinks per day

19. Please select once response for each of the following statements

When I smell a sizzling steak or juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished a meal.	Definitely true	Mostly true	Mostly false	Definitely true
I deliberately take small helpings as a means of controlling my weight	Definitely true	Mostly true	Mostly false	Definitely true
When I feel anxious, I find myself eating	Definitely true	Mostly true	Mostly false	Definitely true
Sometimes when I start eating, I just can't seem to stop	Definitely true	Mostly true	Mostly false	Definitely true
Being with someone who is eating often makes me hungry enough to eat also	Definitely true	Mostly true	Mostly false	Definitely true
When I feel blue, I often overeat	Definitely true	Mostly true	Mostly false	Definitely true
When I see a real delicacy, I often get so hungry that I have to eat right away	Definitely true	Mostly true	Mostly false	Definitely true
I get so hungry that my stomach often seems like a bottomless pit	Definitely true	Mostly true	Mostly false	Definitely true
I'm always hungry so its hard for me to stop eating before I finish the food on my plate	Definitely true	Mostly true	Mostly false	Definitely true
When I feel lonely, I console myself by eating	Definitely true	Mostly true	Mostly false	Definitely true
I consciously hold back at meals in order not to gain weight	Definitely true	Mostly true	Mostly false	Definitely true
I do not eat some foods because they make me fat.	Definitely true	Mostly true	Mostly false	Definitely true
I'm always hungry enough to eat at any time	Definitely true	Mostly true	Mostly false	Definitely true

20. How often do you feel hungry?

□ Only at meal times

□ Sometimes between meals

□ Often between meals

□ Almost always

21. How frequently do you avoid stocking up on tempting foods?

- Almost never
- Seldom
- Usually
- Almost always

22. How likely are you to consciously eat less than you want?

- Unlikely
- Slightly likely
- Moderately likely
- Very likely

23. Do you go on eating binges even though you are not hungry?

- Never
- Rarely
- Sometimes
- At least once a week

24. On a scale of 1 to 8, where 1 means no restraint, and 8 means total restraint what number would you give yourself?

- 1= no restraint in eating (eating whatever you want, whenever you want it)
- 2
- 3
- 4
- 5
- 6
- 7
- 8= total restraint (constantly limiting food and never 'giving in')

The following questions are about exercise and physical activity

25. How many days are you currently doing planned exercise e.g. brisk walking, going to the gym?

- 0 to 1 days
- 2 to 3 days
- 4 to 5+ days

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the vigorous activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think about those physical activities that you did for at least 10 minutes at a time.

26. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics or fast bicycling?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7

27. How much time did you usually spend doing vigorous physical activities on one of those days. Please enter response as minutes per day (i.e. 1 hour= 60, 2 hours=120)

Think about moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

28. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace or doubles tennis?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7

29. How much time did you usually spend doing moderate physical activities on one of those days. Please enter response as minutes per day (i.e. 1 hour= 60, 2 hours=120)

Think about the time you spent walking in the last 7 days. This includes at work, at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise or leisure.

30. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7

31. How much time did you usually spend doing vigorous physical activities on one of those days. Please enter response as minutes per day (i.e. 1 hour= 60, 2 hours=120)

The last question is about time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television.

32. During the last 7 days, how much time did you spend sitting on a week day?

Please enter response as minutes per day (i.e. 1 hour=60, 2 hours=120)

Appendix Five: Statement of contribution and collaboration for Chapter Three

I attest that Research Higher Degree candidate Melinda J Neve contributed to the following paper:

Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis, published in *Obesity Reviews* 2010; Volume 11(4): Page 306-321.

Melinda J Neve contributed to the development of the review protocol, selection of studies for inclusion in the review, critical appraisal of included studies, data extraction, meta-analysis and drafting of the manuscript. Professor Clare E Collins and Associate Professor Philip Morgan contributed to the protocol and manuscript development within the capacity of their role as PhD supervisors. Penelope Jones was the second reviewer for the systematic review, and therefore selected studies for inclusion in the review, critically appraised the included studies and verified data extraction.

Professor Clare E Collins Date

Associate Professor Philip J Morgan Date

Mrs Penelope E Jones Date

Miss Melinda J Neve Date

Professor John Rostas Date

Deputy Dean Faculty of Health (Research and Research Training)

Appendix Six: Statement of contribution and collaboration for Chapter Four

I attest that Research Higher Degree candidate Melinda J Neve contributed to the following paper:

Participant characteristics and reach of a commercial web-based weight loss program, published in *Nutrition & Dietetics* 2010, Volume 67(4): Page 267-264

Melinda J Neve contributed the study design, data analysis and manuscript preparation. Professor Clare E Collins and Associate Professor Philip J Morgan contributed to the study design and manuscript preparation within the capacity of their role as PhD supervisors.

Professor Clare E Collins Date

Associate Professor Philip J Morgan Date

Miss Melinda J Neve Date

Professor John Rostas Date

Deputy Dean Faculty of Health (Research and Research Training)

Appendix Seven: Statement of contribution and collaboration for Chapter Five

I attest that Research Higher Degree candidate Melinda J Neve contributed to the following paper:

Weight change in a commercial web-based weight loss program and its association with website use, currently under review by *The Journal of Medical Internet Research.*

Melinda J Neve contributed to the study design, data analysis and manuscript preparation. Professor Clare E Collins and Associate Professor Philip J Morgan contributed to the study design and manuscript preparation within their capacity as PhD supervisors.

Professor Clare E Collins Date

Associate Professor Philip J Morgan Date

Miss Melinda J Neve Date

Professor John Rostas Date

Deputy Dean Faculty of Health (Research and Research Training)

Appendix Eight: Statement of contribution and collaboration for Chapter Six

I attest that Research Higher Degree candidate Melinda J Neve contributed to the following paper:

Dropout, nonusage attrition, and pre-treatment predictors of nonusage attrition in a Commercial Web-Based Weight Loss Program, published in *Journal of Medical Internet Research,* 2010, 12 (4): e69.

Melinda J Neve contributed to paper through study design, data analysis and manuscript preparation. Professor Clare E Collins and Associate Professor Philip J Morgan contributed to the study design and manuscript preparation within their capacity as PhD supervisors.

Professor Clare E Collins Date

Associate Professor Philip J Morgan Date

Miss Melinda J Neve Date

Professor John Rostas Date

Deputy Dean Faculty of Health (Research and Research Training)

Appendix Nine: Statement of contribution and collaboration for Chapter Seven

I attest that Research Higher Degree candidate Melinda J Neve contributed to the following paper:

Behavioural factors associated with successful weight loss 15-months post enrolment in a commercial web-based weight loss program, currently under review by *Health Education and Behaviour*

Melinda J Neve contributed to the study design, data analysis and manuscript preparation. Professor Clare E Collins and Associate Professor Philip J Morgan contributed to the study design and manuscript preparation within their capacity as PhD supervisors.

Professor Clare E Collins Date

Associate Professor Philip J Morgan Date

Miss Melinda J Neve Date

Professor John Rostas Date

Deputy Dean Faculty of Health (Research and Research Training)

Appendix Ten: Statement of contribution and collaboration for Chapter Eight

I attest that Research Higher Degree candidate Melinda J Neve contributed to the following paper:

Comparison of energy intake estimated by a web-based food diary to total energy expenditure determined by the doubly labelled water method in overweight and obese women, currently under review by *British Journal of Nutrition*.

Melinda J Neve contributed to the study design, participant recruitment, data collection, data analysis and manuscript preparation. Professor Clare E Collins and Associate Professor Philip J Morgan contributed to the study design and manuscript preparation within the capacity of their role as PhD supervisors. Professor Helen Truby contributed to the study design, data interpretation, and manuscript preparation. Professor Peter Davies analysed the DLW samples and contributed to manuscript preparation. Professor Robin Callister contributed to the study design and manuscript preparation.

Professor Clare E Collins Date

Associate Professor Philip J Morgan Date

Professor Helen Truby Date

Professor Peter Davies Date

Professor Robin Callister Date

Miss Melinda J Neve Date

Professor John Rostas Date

Deputy Dean Faculty of Health (Research and Research Training)