Published online on 21 March 2013 J Telemed Telecare, doi: 10.1177/1357633X13479702

Design and pilot results of a mobile phone weight-loss application for women starting a meal replacement programme

Emily Brindal*, Gilly Hendrie†, Jill Freyne†, Mac Coombe‡, Shlomo Berkovsky† and Manny Noakes*

*CSIRO Animal, Food and Health Sciences, Adelaide, Australia; †CSIRO ICT Centre, Marsfield, Australia; ‡CSIRO ICT Centre, Hobart, Australia

Summary

We developed and tested a mobile phone application (app) to support individuals embarking on a partial meal replacement programme (MRP). Overweight or obese women were randomly allocated to one of two study groups. The intervention group received an MRP Support app. The control group received a static app based on the information available with the MRP. A total of 58 adult women (Support $n = 28$; Control $n = 30$) participated in the 8-week trial. Their BMI was 26–43 kg/m^2. Usage data suggested that the intervention group were more engaged with using the app throughout the study period. Mixed modelling revealed that the difference in weight loss between the intervention and control groups (estimated mean, EM = 3.2% and 2.2% respectively) was not significant ($P = 0.08$). Objective data suggested that users of the Support app were more engaged than those using the control app. A total of 1098 prompts (54%) asking people in the intervention group to enter their meals were completed prior to the evening prompt. Women in the intervention group reported a greater increase in positive affect (i.e. mood) than those in the control group (EM = 0.48 and −0.01, respectively) ($P = 0.012$). At Week 8, those in the control group reported a greater decrease in the effort they were willing to put into staying on the diet than those who received the Support app (EM = −2.8 and −1.4, respectively) ($P = 0.024$). The Support app could be a useful adjunct to existing MRPs for psychological outcomes.

Introduction

Obesity remains a problem internationally. Behavioural programmes for weight loss are increasingly using electronic devices but the evidence for their efficacy is inconsistent.[1] Nevertheless, the key components for effective technology-based weight loss interventions include: being based on a structured programme, use of self-monitoring, providing feedback and communication, giving social support, and individual tailoring.[2]

Mobile phones have advantages for the delivery of e-health interventions. For example, mobile phone messages can make personalised feedback easier and provide immediate feedback and behavioural prompting.[3,4] Mobile phones using text messaging and monitoring have been shown to be useful additions to health programmes.[5] A text message-based phone intervention based on changing food intake and monitoring weight daily with feedback, was found to be effective for weight loss up to 12 months.[6] The frequency of use halved during the study, but maintaining contact was positively associated with successful weight loss.[6]

Despite the potential efficacy of text messaging through behavioural prompting, this technique does not utilise the full potential of smartphone technologies. Many commercial mobile phone applications (apps), including healthy eating and diet programme apps, are emerging but most have been developed without a theoretical base and lack scientific evaluation of their efficacy.[7] Few studies on scientifically derived and tested apps utilising more than texting messaging have been published.[8]

There is evidence to support the use of mobile phones as an adjunct to treatment programmes, but little is known about the efficacy of phone-delivered behavioural interventions with limited contact. We are only aware of one study that has incorporated efficacious behavioural techniques (i.e. self-monitoring) and smartphones.[8] The objective of the present study was to develop and evaluate a weight-loss intervention delivered by a smartphone app that supported individuals embarking on a diet and that was evidenced-based.

Accepted 30 January 2013
Correspondence: Dr Emily Brindal, PO Box 10041, Adelaide BC, SA 5000, Australia (*Email: emily.brindal@csiro.au*)

Methods

The study was approved by the appropriate ethics committee and registered in the national clinical trials register (ACTRN12611000693921). The study was an 8-week weight loss trial that involved overweight or obese women randomly allocated to one of two study groups using a computer-generated sequence. Participants were blinded as to their allocations. Both groups were instructed to follow a commercially-available partial meal replacement programme (MRP). Commercial meal replacements are a popular strategy among people trying to lose weight and can be as effective as other styles of diet.[9]

The intervention group received an MRP app. The control group received an app that reproduced the information available with the MRP. The study comprised two phases: during the first four weeks meal replacements were provided to participants (feasibility phase), and during the second four weeks participants were required to purchase their own meal replacements if they wished to continue on the diet (free-living phase).

Participants attended the Clinical Research Unit for assessment on five occasions (baseline, week 2, week 4, week 6 and week 8). At all visits, height and bodyweight were measured and participants completed a computer-administered questionnaire. No advice regarding the weight management programme was provided at these visits. At the baseline visit, one of the two apps was installed on the participant's smartphone and a short tutorial about the app provided.

After baseline assessment, participants only had contact with the trial manager (e.g. for organising appointments) or a study email address. Twenty emails were received during 8 weeks. These related to the absence of prompts during an unexpected system outage ($n = 6$), requests for changes to user settings or to reinstall the app ($n = 9$) or seeking confirmation that the app was not "doing anything" ($n = 5$, all in the control group).

Participants

The participants were adult women with a self-reported body mass index (BMI) greater than 25 kg/m^2, who owned an iPhone, were willing to participate in the study, and had the ability to measure their weight at home (i.e. access to bathroom scales). People with medical conditions that were likely to interfere with their ability to undertake the MRP were excluded (including pregnancy, breast feeding, active cancer, gastrointestinal disorders and Type 1 diabetes). The study was limited to women as gender differences can affect response to treatment.

Based on the weight losses in women on previous meal replacement programmes[10] and a 30% drop out rate, the aim was to recruit 30 women per group (statistical power of 0.08 to detect a difference between groups at $P < 0.05$). A newspaper advertisement and an established volunteer database were used to recruit the sample.

Diet

All participants were provided with information on their phone about the Celebrity Slim MRP (Celebrity Slim Probiotec, Laverton North, Australia). Celebrity Slim is not a calorie counting approach to dieting but focuses on restricting energy intake by replacing two ordinary meals with meal replacement shakes. Participants are not required to calorie count, although this is encouraged for longer term maintenance of weight loss. The Celebrity Slim programme recommends replacing two meals with two meal replacements (pre-packaged formulated shakes) each day. In addition to meal replacements, participants can have one balanced meal, for which suggested recipes are provided (e.g. grilled chicken breast with salad, Spanish omelette, lamb and vegetable stir fry) and up to three snacks each day as defined in the programme guide (e.g. a piece of fruit, low fat cottage cheese with celery sticks, handful of almonds, berries and yoghurt). The guide formed the complete app for the control group, while it was only one aspect of the Support app.

Intervention

The Support app provided information, simplified food intake recording, rewarded positive behaviour and prompted regular interaction through reminders and self-monitoring of weight and diet. The application communicated with a web service in order to record user data, perform processing, log events and deliver content. When participants logged into the app, they were directed to the dashboard. Here they could access the main features of the Support app: a meal calendar (My Meals), a weight tracker (My Weight), a log of tasks to be completed (My Tasks), a trophy room where unlocked rewards could be viewed (Trophies), the static dietary information (Information) and customisable settings (Settings) (Figure 1).

Prompting

Prompting was implemented using the Apple Push Notification Service with task notifications appearing on the smartphone's main screen. Prompts occurred three times daily, corresponding to waking and typical meal times. The first prompt asked participants to record their weight (morning) while the second (afternoon) and third (evening) prompts asked participants to fill in the meal diary. The exact timing of the prompts could be customised (in the settings menu) and the afternoon prompt could be disabled. Response to the prompt was designed to require little participant interaction. At any other time participants were free to access the app by logging in. For example, if they wished to check their data or enter new meal data, they could click on My Meals and My Weight (Figure 1e).

If afternoon and evening prompts were not completed prior to the subsequent one, these tasks became overdue and appeared in the My Tasks section of the dashboard.

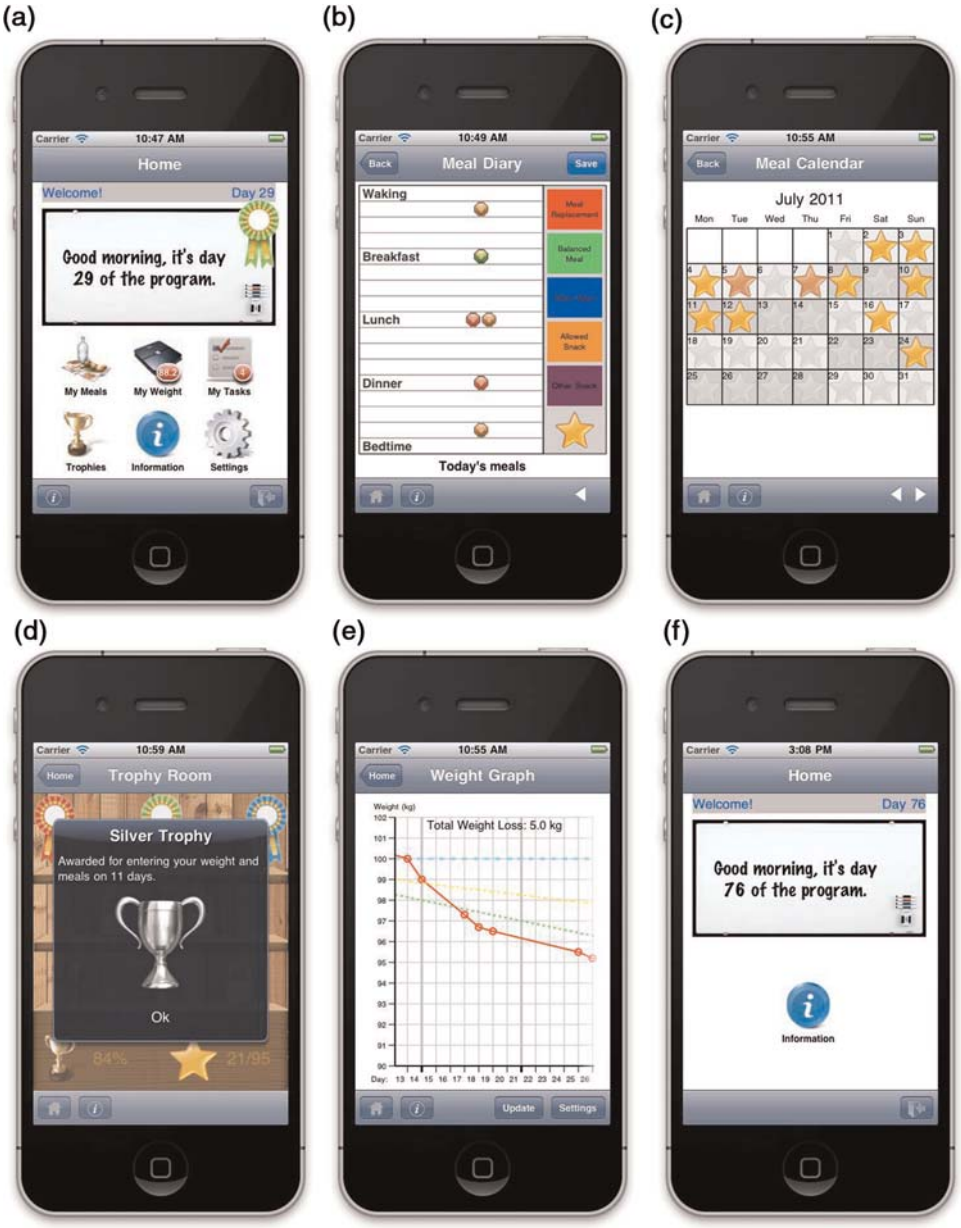

Figure 1 Screenshots of apps (a) the App Dashboard, which was accessed following login (b) Meal Diary interface (c) Meal Calendar presenting dietary compliance (d) Trophy room depicting the award of a new trophy (e) The weight graph under MyWeight shows a regression line for the observed weight loss, an ideal weight loss line (set at one kilogram per week) and a motivational weight loss line that shows whether the user is on track to meet their personal weight loss goal, which they defined when the application was installed (f) Dashboard for the control app

When participants logged in, they were informed of the number of overdue tasks they had and were given an opportunity to complete them. The weight entry prompt could not become overdue and disappeared if not completed in the morning.

Meal and weight monitoring

The meal calendar was designed to encourage dietary monitoring while also providing feedback regarding dietary compliance. Food intake recording was achieved through a simple drag and drop interface (Figure 1b). Meals were characterised using five simple categories: meal replacements, balanced meals, other meals, allowed snacks and other snacks. A user simply selected the food category representing their intake (e.g. balanced meal) and dragged it onto the appropriate part of the timeline. These were recorded and presented categorically only, with no accompanying kilojoule values stored. Daily compliance was communicated simultaneously with the entry of meals through a star system (gold, silver, bronze or no star) using a simple scoring system (Figure 1c).

Weights were entered through a spinner which presented the existing value and could be adjusted appropriately each

morning (in response to a prompt) or at any time throughout the day.

Support/feedback

A message board in the dashboard displayed greetings, motivational messages and thoughts for reflection on diet progress from a database of responses. These messages targeted self-regulation and planning in accordance with the Health Action Process Approach.[11] This was designed to assist individuals to shift from pre-intention to behaviour primarily through planning strategies and goal setting. The Support app utilised only the volitional phase of this model as by enrolling in the study, participants had already progressed through the motivational (pre-intention) phase. As the goals of the participants were fixed (consume two meal replacements and up to three allowable snacks a day), the app focussed mainly on the planning aspect of this approach. Motivational messages focussed on action planning ("Planning ahead will help you to stick to your goals"), coping planning ("Don't focus on your failures, learn from them"), general encouragement ("All great achievements take time. Hang in there") and self-reflection ("Do you think that you are getting better at planning to stick to your diet?"). During the initial weeks of the trial, these messages focussed on action planning and shifted to focus on coping planning (addressing barriers to maintaining behaviour change).[11]

At the end of each week users received tailored feedback messages, which reflected their progress to date based on their reported compliance to the MRP and their weight loss. Participants doing well were positively reinforced for their success while those who were falling short of dietary and/or weight loss goals were provided with general encouragement.

Finally, to encourage weight and meal entries, users were awarded virtual ribbons and trophies for regular interaction (8 in total) (Figure 1d). The algorithm for these rewards was based largely on user interaction, although dietary compliance also had to meet a minimum standard.

Study measures and outcomes

The principal outcomes related to user engagement/interaction and to weight loss. The secondary outcomes were a user evaluation of the app and behavioural outcomes, including mood and motivation.

Principal outcomes

Percentage weight loss from baseline was calculated based on the weight values recorded at the clinic visits. Participants were weighed and measured with a stadiometer while lightly clothed and without shoes.

Usage data

All user interaction with the control and intervention apps was automatically logged by the server. The interaction logs noted the timestamp, the user identifier, user action type (login, bodyweight recording, food recording, menu selection, page/graph/calendar view), data entered (weight entered, meal type added/removed) and the response from the application (trophy awarded, feedback presented).

Secondary outcomes

An evaluation survey with 10 questions was completed by both groups at week 4 and 8 during a clinic visit. Qualitative questions asked participants about features they particularly liked/disliked and requested general feedback. The Support app group were asked to complete an additional questionnaire including 27 items evaluating specific features of the Support app at week 4. These questions included rating the ease of completing a task, entering meals, entering weights and finding relevant information. Participants were also asked how useful and how much they liked eight aspects of the app including the meal calendar, meal diary, meal graph, weight tracker, prompting, trophy room, information/settings and help menu.

Behavioural outcomes

At weeks 0, 4 and 8 participants completed a computer-administered behavioural questionnaire. This assessed positive and negative affect (PANAS)[12] using subscales of positive affect and negative affect. The PANAS is a validated and widely used measure of mood which asks participants to indicate the extent to which they feel 20 different moods.

Several outcomes were developed based on the Theory of Planned Behaviour (TPB).[13] Items assessing perceived motivation were asked in the format: "I will try to [behaviour] for the next 4 weeks" and "I will plan to [behaviour] for the next 4 weeks" and answered on a 7-point Likert style scale. These items were asked relating to staying on the MRP ($\alpha = 0.78$) as well as using the mobile phone app ($\alpha = 0.76$). The four items used to assess perceived behavioural control over staying on the MRP (e.g. "If I wanted to, I could stick to the meal replacement programme for the next 4 weeks") showed good reliability ($\alpha = 0.77$).

For the PANAS and TPB items, values were calculated as a change from baseline with negative scores representing a decrease in the constructs. Every fortnight participants were asked about their perceived compliance with the MRP which was rated in 10% increments from 0 (not at all compliant) to 11 (100% compliant) as well as how frequently they had been weighing themselves.

User characteristics

At the baseline visit prior to uploading the app, participant characteristics were recorded. This included age, occupation, duration of iPhone ownership and level of education.

Statistical analysis

All outcomes were assessed using mixed models with an unstructured covariance matrix. This method includes all available data and is therefore an intention-to-treat analysis. The models assessed main effects for intervention condition, week and the interaction between the two. A standard package was used (IBM SPSS Statistics 20, New York, US). Post-hoc comparisons with Bonferroni adjustments were made for intervention condition (Support versus control app) where a significant interaction was present. For comparisons of weight loss, perceived behavioural control, perceived motivation and mood, scores were calculated as a change from baseline. For change measures, baseline scores were entered into the model as a covariate as baseline values are often correlated with change scores.

Results

The sample was 58 women aged 19–63 years (mean 42), with an average weight of 92.4 kg (SD = 14.7) and BMI 26–43 kg/m^2 (mean 34). The majority of the women were born in Australia (88%), employed full time (46%), and had a technical diploma (42%) or were tertiary educated (37%). Most women had never dieted using MRP (72%) and had owned their smartphone for more than three months (80%). At the end of 8 weeks, 76% of those randomised finished, with no difference in drop-outs between the two groups ($P > 0.44$) (Figure 2).

Feasibility

The usage data suggested that the Support app group were more engaged with using the application throughout the study period (Figure 3). Higher usage of the app was accompanied by a smaller net decline in perceived motivation to use the application throughout the study period in the Support app group: the Estimated Mean (EM) from the mixed model was −0.62, relative to the control group (EM = −3.61) ($P < 0.001$). There was a significant effect of week of intervention (change from baseline at week 4 and 8) on change in motivation ($P = 0.003$). The effect of week did not interact with the intervention condition.

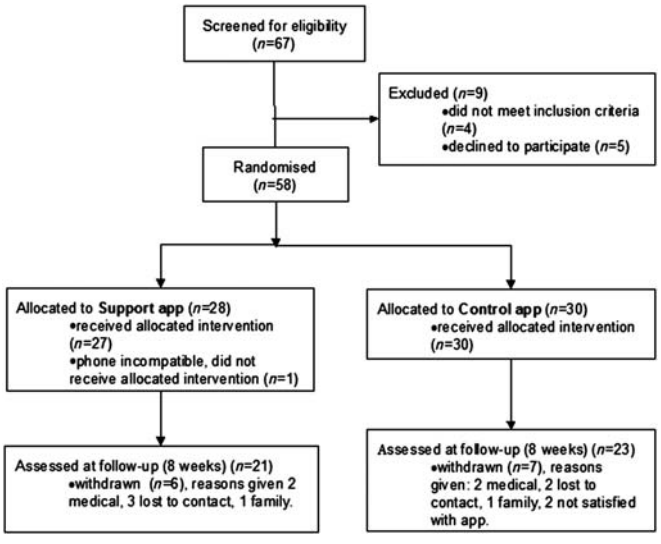

Figure 2 CONSORT flow diagram from volunteer recruitment to analysis of final results

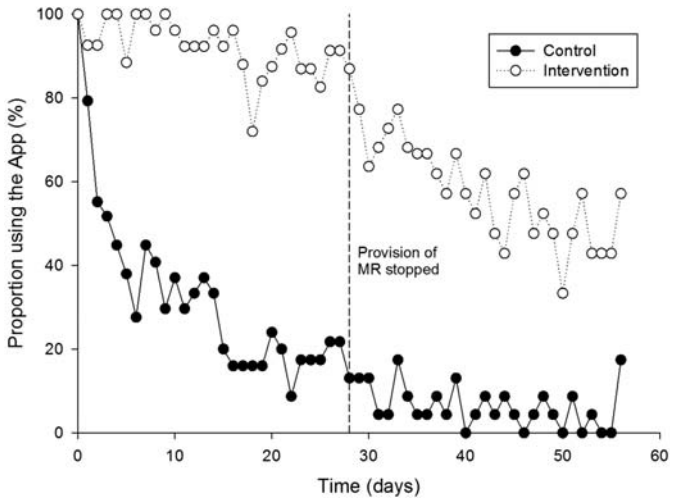

Figure 3 Proportion of participants using the mobile phone application during the study

Weight loss

Both groups lost weight during the study period (Figure 4). The pooled difference in weight loss between the groups favoured the intervention group (EM = 3.18%, SE = 0.38) over the control group (EM = 2.22%, SE = 0.37), but was not significant ($P = 0.08$), see Table 1. There was a significant main effect for week ($P = 0.007$). Treatment and week did not interact significantly.

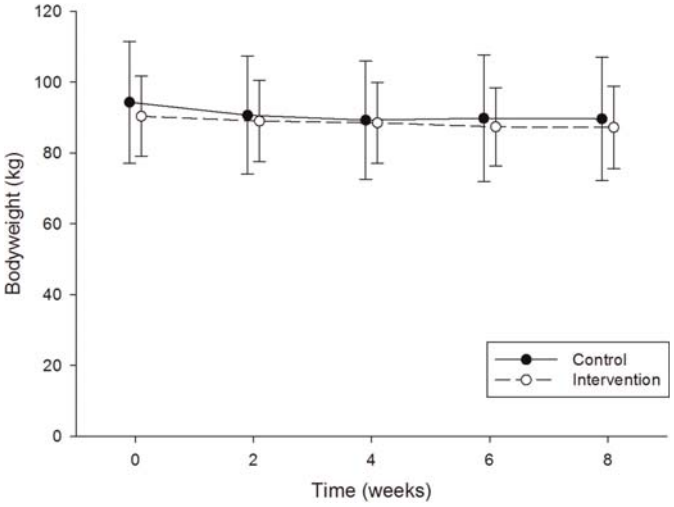

Figure 4 Mean bodyweights in the two groups. The error bars represent SDs

Table 1 Estimated means and standard errors (SE) from mixed models analysis. Positive changes represent an increase in the construct from baseline

	Support App					Control App					Effects	
	Week 2	Week 4	Week 6	Week 8	Total	Week 2	Week 4	Week 6	Week 8	Total	*P*-value App	*P*-value App by Week
Weight loss (%)	2.5 (0.3)	2.9 (0.4)	3.6 (0.5)	3.8 (0.6)	3.2 (0.4)	1.8 (0.2)	2.2 (0.4)	2.5 (0.4)	2.5 (0.6)	2.2 (0.4)	0.079	0.74
Frequency of weighing[a]	4.9 (0.2)	4.7 (0.2)	4.0 (0.3)	3.9 (0.3)	4.4 (0.2)	3.2 (0.2)	3.1 (0.2)	2.8 (0.3)	2.7 (0.3)	2.9 (0.2)	< 0.001	0.57
Dietary compliance[b]	8.6 (0.3)	8.5 (0.4)	5.8 (0.4)	6.8 (0.6)	7.4 (0.3)	8.9 (0.3)	8.0 (0.4)	6.6 (0.4)	6.8 (0.6)	7.6 (0.3)	0.69	0.028†
Change from baseline												
Positive affect[c]	–	0.38 (0.16)	–	0.59 (0.15)	0.48 (0.14)	–	−0.01 (0.15)	–	−0.01 (0.14)	−0.01 (0.13)	0.012	0.32
Negative affect[c]	–	0.03 (0.17)	–	−0.15 (0.14)	−0.06 (0.13)	–	−0.01 (0.16)	–	−0.10 (0.13)	−0.12 (0.12)	0.76	0.36
Effort to stay on MRP[d]	–	−1.00 (0.34)	–	−1.42 (0.43)	−1.21 (0.33)	–	−0.73 (0.33)	–	−2.83 (0.42)	−1.78 (0.32)	0.22	0.005‡
Perceived behavioural control over staying on MRP[d]	–	−0.06 (0.25)	–	−0.58 (0.30)	0.60 (0.24)	–	−0.59 (0.24)	–	−0.93 (0.28)	−0.76 (0.22)	0.62	0.36

†Intervention apps did not differ significantly at any week (all $P > 0.05$)
‡Intervention apps differed significantly at week 8 ($P = 0.024$)
[a]1 = Not at all, 2 = Rarely, 3 = Sometimes, 4 = Most days, 5 = Daily
[b]0 = not at all compliant to 11 (100% compliant)
[c]Scores range from 1 to 5
[d]Scores range from 1 to 7

At week 8, 23% and 21% of the people in the control and intervention groups respectively had lost bodyweight considered to be clinically relevant (i.e. 5% or more). There was no difference in these proportions between interventions ($P > 0.86$).

Acceptance/usage of App

Throughout the 8 weeks, the Support app group perceived that they weighed themselves more frequently than the control group (Table 1). To evaluate the reaction to prompting in the Support app group over the course of the trial, we assessed the number of prompts sent and completed prior to the subsequent prompt (i.e. before they became overdue and disappeared). Of 1279 morning prompts to enter bodyweight, 68% were completed. There was no effect of app type on perceived dietary compliance to the MRP (Table 1).

To assess objective dietary compliance in the Support app group, meal data entered throughout the study period by participants were collated. A high proportion of the active users (non drop-outs) entered their meals throughout the study period, although there appeared to be a slight decline after cessation of meal replacement provision. Full compliance with the MRP was low and fell throughout the study period (Figure 5).

A total of 1098 prompts (54%) asking people to enter their meals were completed prior to the evening prompt. Completion of the evening meal entry prompts was similar (53% of the 1230 prompts responded to prior to morning prompt).

There was a significant interaction effect between intervention condition and time for effort to stay on the MRP (Table 1). At Week 8, those in the control group reported a greater decrease in the effort they were willing to put into staying on the diet relative to the Support app group ($P = 0.024$). Values were not significantly different at

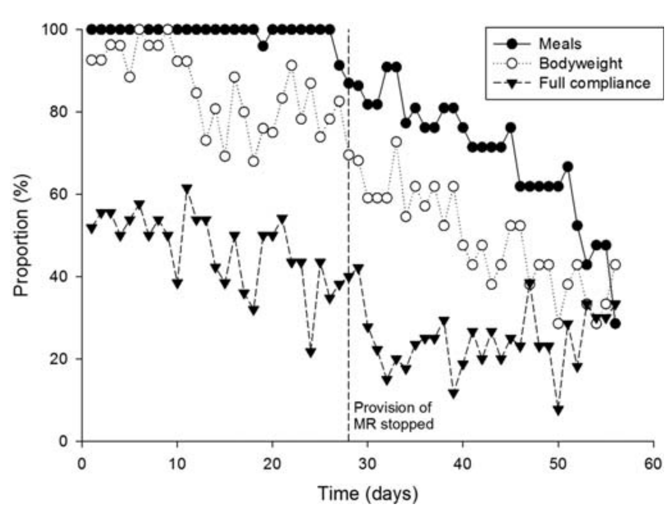

Figure 5 Proportion of users in the Support app group who entered bodyweight or meal data, or who entered meals that were completely compliant with the meal replacement programme

Table 2 Responses to questionnaire on ease of use, perceived usefulness and liking of key features. Responses were rated 1 = Not at all, 2 = Slightly, 3 = Moderately, 4 = Extremely

2A. How easy did you find it to:

	Mode	Not at all % (*n*)	Extremely % (*n*)
... complete a task	4	0 (0)	73 (16)
... enter your meals	4	0 (0)	77 (17)
... enter your weights	4	0 (0)	77 (17)
... find relevant information	4	0 (0)	59 (13)

2B. How useful did you find (or how much did you like) the following features?

	Useful Mode	Not at all % (*n*)	Extremely % (*n*)	Like Mode	Not at all % (*n*)	Extremely % (*n*)
My Weight* (Figure 1e)	4	0 (0)	77 (17)	4	5 (5)	68 (15)
Task notifications	4	0 (0)	64 (14)	4	0 (0)	59 (13)
My Meals						
Meal diary (Figure 1b)	4	0 (0)	41 (9)	3	0 (0)	41 (9)
Meal calendar (Figure 1c)	3	23 (5)	14 (3)	3	27 (6)	23 (5)
Meal graph*	1	27 (6)	23 (5)	1	27 (6)	27 (6)
Information						
Tutorials/help	3	9 (2)	18 (4)	3	5 (5)	18 (4)
Additional information	3	9 (2)	23 (5)	3	5 (5)	23 (5)
Trophies (Figure 1d)	1	41 (9)	14 (3)	1	36 (8)	9 (2)
Settings	3	9 (2)	23 (5)	3	5 (5)	23 (5)

*Alternative visualisation of meal calendar

Week 4. There were no differences between interventions in perceived behavioural control to stay on the MRP (Table 1).

Mood

There was a significant difference in change in positive affect between the apps. Means indicated a net increase in positive affect (EM = 0.48, SE = 0.14) for the Support app group relative to the control group (EM = −0.01, SE = 0.13) over the 8 weeks (Table 1). In both groups there was a moderate correlation between the percentage of weight lost at week 8 and changes in positive affect. This relationship was not significant in the Support app group ($r = 0.41$, $P = 0.063$) but was significant in the control group ($r = 0.51$, $P = 0.004$). There were no significant differences between apps for changes in negative affect.

User evaluation

Feedback from participants suggested that the Support app was well received. A high proportion of Support app participants (95%) felt that the app helped them to stick to the diet to some extent compared to 9% of participants who received the control app.

Most of the completers ($n = 19$, 91%) would recommend the Support app to someone else if they were embarking on a MRP. No one in the control group agreed with this item. In the Support app group, 14 (67%) people wanted to extend their access to the programme past the study period, while 15 (71%) indicated that they would purchase the app if it was available at a reasonable price. Only one person (4%) in the control group would have purchased the app. Five people (22%) indicated that they would like to extend their access to the control app.

Ratings of ease of use and specific features of the Support app by the completers in this group ($n = 21$) are shown in Table 2. Most participants found it extremely easy to complete the basic functions of the app. The weight tracker and prompting were the most popular features while the trophies and meal graph (visual presentation) were the least popular.

Discussion

The present study investigated the efficacy of a smartphone app to support dieters on a MRP. Objective data from participants indicated that they engaged with the Support app, and the subjective evaluation data was largely positive. However, there was no significant difference in weight loss between the intervention and control groups. There were some psychological benefits for those in the intervention group relative to control, including significant improvements in mood and a smaller reduction in motivation to stay on the MRP.

We had anticipated that our control group would stop the MRP earlier than the intervention group and therefore stop losing weight. However, perceived dietary compliance and weight loss was not different between the two apps at any of the testing points. On average, both groups experienced weight loss after 8 weeks. Observer effects and the initial provision of the meal replacements may help to explain the null effect for weight loss for the different treatments. Although the trial was performed over a relatively short period, there has been suggestion that initial weight loss is predictive of continued weight management.[14]

Over 8 weeks, using a similar dietary programme, Moran *et al.*[10] reported average losses of 6% with a much higher proportion of people achieving clinically relevant losses (75%). However, this programme was facilitated through face-to-face support. Other phone-based interventions using different dietary programmes have reported weight losses of between 3.2%[15] and 5.3%[6] over 12 weeks.

The relationship between mood and weight loss has been well-documented.[16] While we found some evidence of this relationship, it was only those with the Support app who reported an increase in positive affect. Even though both groups lost weight, those who received the Support app may have experienced positive effects on their mood due to their increased engagement with the weight loss programme. Objective data about interactions confirm there was higher engagement with the Support app.

It was clear that both groups had a decrease in their motivation to stay on the MRP after 8 weeks. The difference in change in motivation favoured the Support app at 8 weeks, but not at 4 weeks. While meal replacements were provided until week 4, from weeks 4 to 8 they were not, meaning that participants had to purchase their own products to stay on the diet, introducing additional barriers. It was during this free-living period that we witnessed a drop in the motivation for both groups but this effect was more pronounced in the control group.

The results of the present study suggest that self-monitoring and prompting are promising components of mobile-phone delivered interventions. Prompting acts to remind people about behaviours, thereby increasing the likelihood that the behaviour can become habitual.[17] We focused on monitoring as a target behaviour rather than consuming meal replacements (i.e. reminding people to eat their meal replacements) given the importance of self-monitoring for successful weight loss.[18,19] Monitoring dietary intake can be a mentally draining task with some research indicating that dieters suffer from cognitive impairment.[20] Constant dietary restriction through dieting may also fatigue the ability to self-regulate behaviour.[21,22] Therefore, prompting and technological support may reduce some of the psychological burden created by dieting which could assist dieters in successful behaviour change. Our finding regarding the protective effect of the Support app for motivation provides preliminary support for this concept (i.e. participants' motivation was not as drained). Incorporating more dynamic stage-based tailoring as participants change their behaviours may further enhance similar apps in the future.[11]

Overall, usage of the intervention app was promising. However, from week 4 to 8 of the study, those who received the Support app seemed to reduce their engagement with the app and reported compliance to the MRP. Despite our attempt to incorporate gamification[23] through the trophy room, this was a poorly rated feature of the Support app. Gaming inspired features have been found to work in other fields such as e-learning.[24] It is unclear what made the trophy room unpopular.

The present study had certain limitations. First, the aim of the study was to test a programme, so we could not ascertain if there was a single critical feature (e.g. prompting or self-monitoring) that explained any differences between the Support and control apps. Second, the trial included only women. Third, the app was programmed only for iPhone users, although other smartphones are becoming popular. Finally, participants were required to attend the clinic to have their weights assessed.

In conclusion, although its efficacy for weight loss has not been established, these preliminary data suggest that the MRP Support app has the potential to increase positive mood and maintain motivation during a weight loss programme.

Acknowledgements: We thank Celebrity Slim for providing us with some samples of their breakfast and snack bars. We also thank Anne McGuffin for acting as the trial manager. The trial was funded by CSIRO Food and Nutritional Sciences (now CSIRO Animal, Food and Health Sciences) and the CSIRO ICT Centre.

References

1 Norman GJ, Zabinski MF, Adams MA, Rosenberg DE, Yaroch AL, Atienza AA. A review of eHealth interventions for physical activity and dietary behavior change. *Am J Prev Med* 2007;**33**:336–345
2 Khaylis A, Yiaslas T, Bergstrom J, Gore-Felton C. A review of efficacious technology-based weight-loss interventions: five key components. *Telemed J E Health* 2010;**16**:931–8
3 Cole-Lewis H, Kershaw T. Text messaging as a tool for behavior change in disease prevention and management. *Epidemiol Rev* 2010;**32**:56–69
4 Fry JP, Neff RA. Periodic prompts and reminders in health promotion and health behavior interventions: systematic review. *J Med Internet Res* 2009;**11**:e16
5 Krishna S, Boren SA, Balas EA. Healthcare via cell phones: a systematic review. *Telemed J E Health* 2009;**15**:231–240
6 Haapala I, Barengo NC, Biggs S, Surakka L, Manninen P. Weight loss by mobile phone: a 1-year effectiveness study. *Public Health Nutr* 2009;**12**:2382–91
7 West JH, Hall PC, Hanson CL, Barnes MD, Giraud-Carrier C, Barrett J. There's an app for that: content analysis of paid health and fitness apps. *J Med Internet Res* 2012;**14**:e72
8 Mattila E, Lappalainen R, Pärkkä J, Salminen J, Korhonen I. Use of a mobile phone diary for observing weight management and related behaviours. *J Telemed Telecare* 2010;**16**:260–4
9 Noakes M, Foster PR, Keogh JB, Clifton PM. Meal replacements are as effective as structured weight-loss diets for treating obesity in adults with features of metabolic syndrome. *J Nutr* 2004;**134**:1894–9
10 Moran LJ, Noakes M, Clifton PM, Wittert GA, Williams G, Norman RJ. Short-term meal replacements followed by dietary macronutrient restriction enhance weight loss in polycystic ovary syndrome. *Am J Clin Nutr* 2006;**84**:77–87
11 Schwarzer R. *Modeling Health Behavior Change: The Health Action Process Approach (HAPA)*. See http://web.fu-berlin.de/gesund/publicat/ehps_cd/health/hapa.htm (last checked 16 January 2013)
12 Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. *J Pers Soc Psychol* 1988;**54**:1063–70
13 Francis J, Eccles M, Johnston M, *et al*. *Constructing Questionnaires Based on the Theory of Planned Behaviour*. Newcastle, UK: Centre for Health Services Research, 2004
14 Astrup A, Rössner S. Lessons from obesity management programmes: greater initial weight loss improves long-term maintenance. *Obes Rev* 2000;**1**:17–9

15 Patrick K, Raab F, Adams MA, *et al*. A text message-based intervention for weight loss: randomized controlled trial. *J Med Internet Res* 2009;**11**:e1
16 Blaine BE, Rodman J, Newman JM. Weight loss treatment and psychological well-being: a review and meta-analysis. *J Health Psychol* 2007;**12**:66–82
17 Tobias R. Changing behavior by memory aids: a social psychological model of prospective memory and habit development tested with dynamic field data. *Psychol Rev* 2009;**116**:408–38
18 Wing RR, Phelan S. Long-term weight loss maintenance. *Am J Clin Nutr* 2005;**82**(Suppl. 1):222–225
19 Michie S, Abraham C, Whittington C, McAteer J, Gupta S. Effective techniques in healthy eating and physical activity interventions: a meta-regression. *Health Psychol* 2009;**28**:690–701
20 Green MW, Rogers PJ, Elliman NA, Gatenby SJ. Impairment of cognitive performance associated with dieting and high levels of dietary restraint. *Physiol Behav* 1994;**55**:447–52
21 Baumeister RF, Heatherton TF. Self-regulation failure: an overview. *Psychol Inq* 1996;**7**:1–15
22 Hagger MS, Wood C, Stiff C, Chatzisarantis NL. Ego depletion and the strength model of self-control: a meta-analysis. *Psychol Bull* 2010;**136**:495–525
23 Deterding S, Dixon D, Khaled R, Nacke L. From game design elements to gamefulness: defining "Gamification". p9–15 in *Proceedings of MindTrek '11*. 28–20 September 2011; Tampere, Finland
24 Muntean CI. Raising engagement in e-learning through gratification. p323–9 in *ICVL 2011 – The 6th International Conference on Virtual Learning*. 28–29 October 2011 Bucharest, Romania