

Regular self-weighing to promote weight maintenance after intentional weight loss: a quasi-randomized controlled trial

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ABSTRACT

Background Many overweight people take action to lose weight but most regain this weight.

Purpose To examine the effectiveness of a weight maintenance intervention focused on regular self-weighing after receiving a 12-week weight loss programme.

Methods Quasi-randomized controlled trial of 3768 obese or overweight men and women. The intervention group ($n = 3290$) received two telephone calls, the offer of free weighing scales, encouragement to weigh themselves weekly and record this on a card. The main outcome was change in weight between 3 and 12 months.

Results Using intention to treat analysis both groups regained weight; however, the intervention group on average regained 1.23 kg, whereas the control group regained 1.83 kg. Adjusting for covariates resulted in a mean difference of 0.68 kg (95% CI 0.12, 1.24) at 12-month follow-up.

Conclusions Encouraging people who have recently lost weight to weigh themselves regularly prevents some weight regain.

Keywords behaviour change, obesity, self-weighing, weight maintenance

Introduction

Compared with weight loss trials, few studies have focused on weight maintenance. Maintenance trials are important because people almost invariably regain weight after weight loss; therefore, finding effective strategies to minimize this is critical. Systematic reviews of weight loss maintenance studies have found self-monitoring, opportunities for social comparison, peer/social support and maintaining contact with participants can reduce weight regain.^{1–4} Research has indicated that self-weighing may be a useful method of self-monitoring for both weight loss and maintenance.^{1,3} The potential efficacy of self-weighing has been based on self-regulation theory.⁵ Self-regulation is a process involving conscious efforts to monitor oneself, evaluate against goals which can reinforce behaviour.^{5,6} Self-weighing can show the individual how their behaviour affects their weight and allows them to adjust their behaviour to achieve their goals.⁷

Some studies^{8,9} have included self-weighing as part of an extensive multi-component intervention, but only three randomized controlled trials (RCTs)^{10–12} have tested a self-weighing intervention where the effects of regular self-weighing could be isolated. In one case, the intervention focused on weight loss,¹¹ one on weight maintenance¹⁰ and the third on both.¹² All were small (ranging from $n = 23–89$), contained other methodological concerns such as short follow-up, making it difficult to draw conclusions.

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Nevertheless two^{10,12} weight maintenance trials reported greater weight loss in participants allocated to self-weighing, suggesting this may be effective for weight maintenance.

Lighten up

In 2008 South Birmingham Primary Care Trust (SB PCT) commissioned the Lighten Up service; this provided National Health Service (NHS) patients with a free course of weight loss treatment for 3 months. The initial users of the service were enrolled in an RCT^{13,14} to test the effectiveness of six weight loss treatments in primary care. Participants were randomized to a comparator group, or one of six weight loss treatments or a choice of the six. The treatments were one-to-one pharmacist support, one-to-one general practice-based support, an NHS group-based programme, Weight Watchers, Slimming World and Rosemary Conley (full description provided elsewhere).¹³

Based on the results of the Lighten Up RCT,¹⁴ the Lighten Up service commissioned four treatment providers for continued use: Weight Watchers, Rosemary Conley, Slimming World and NHS group-based programme. Patients could choose their weight loss treatment and the PCT commissioned a telephone call centre to administer the service and provide a weight maintenance intervention. The weight maintenance intervention encouraged self-weighing. Using routinely collected data from the Lighten Up service we have taken the opportunity to examine the effectiveness of this self-weighing maintenance intervention by comparing weight change in participants in the Lighten Up RCT, where participants received no maintenance intervention, with users of the Lighten Up service, who were offered the weight maintenance intervention.

Methods and procedures

Setting and recruitment of participants

In both groups general practitioners (GPs) referred people who wanted to follow a weight loss treatment and who met eligibility criteria to the Lighten Up call centre either by letter or in a consultation. GPs searched their lists for patients of ≥ 18 years with a raised BMI recorded in the previous 15 months (Box 1). Interested patients telephoned a call centre where the treatment was explained. In the Lighten Up RCT, participants consented to be randomized and in the Lighten Up service they chose their weight loss treatment (see Fig. 1). In one arm of the RCT, participants were given a choice of treatments. Participants who chose their treatment lost the same weight as those who were allocated randomly; therefore, there is no reason to believe that choice, which all users of the service had, played any role in the results.

Box 1 Participant inclusion and exclusion criteria.

- Raised BMI was defined as South Asians with no comorbidities and BMI ≥ 25 kg/m² or with comorbidities and BMI ≥ 23 kg/m².
- All other ethnic groups (except South Asians) with no comorbidities and BMI ≥ 30 kg/m² or with comorbidities and BMI ≥ 28 kg/m².
- The GP excluded patients who had a medical contraindication for any of the weight loss treatments.

Allocation

Lighten Up RCT participants were allocated to the control group (no weight maintenance intervention) and Lighten Up service participants to the intervention group (weight maintenance intervention) based solely upon when they were recruited. The control group was recruited from January to May 2009 and subsequent patients were enrolled into the intervention group from May 2009 to March 2010. Allocation was based on these two time periods and could not be influenced by participants or researchers (i.e. quasi randomized; see Fig. 1).

Primary outcome and assessments

The intervention aimed to prevent weight regain after a period of weight loss; therefore, the primary outcome was change in weight between end of the weight loss treatment at 3 months and 9 months later, i.e. 12 months after starting the weight loss treatment and herein referred to as 12-month follow-up. Both groups were weighed at baseline, prior to commencing the weight loss treatment. Both groups were weighed at the end of the weight loss treatment if they remained in contact with the provider and otherwise self-reported weight data were obtained. At 12 months, the intervention group self-reported weight only, whereas the control group was weighed.

Demographic information

Participants reported their age, gender, ethnicity, postcode and occupation at baseline. Postcode was used to derive the index of multiple deprivation (IMD) and were categorized into quartiles.¹⁵ Height was collected at baseline and BMI calculated at baseline, 3 and 12 months.

Weight maintenance intervention

The call centre contacted participants in the intervention group upon completion of their 3-month weight loss treatment to ask if they were interested in receiving a 3-month

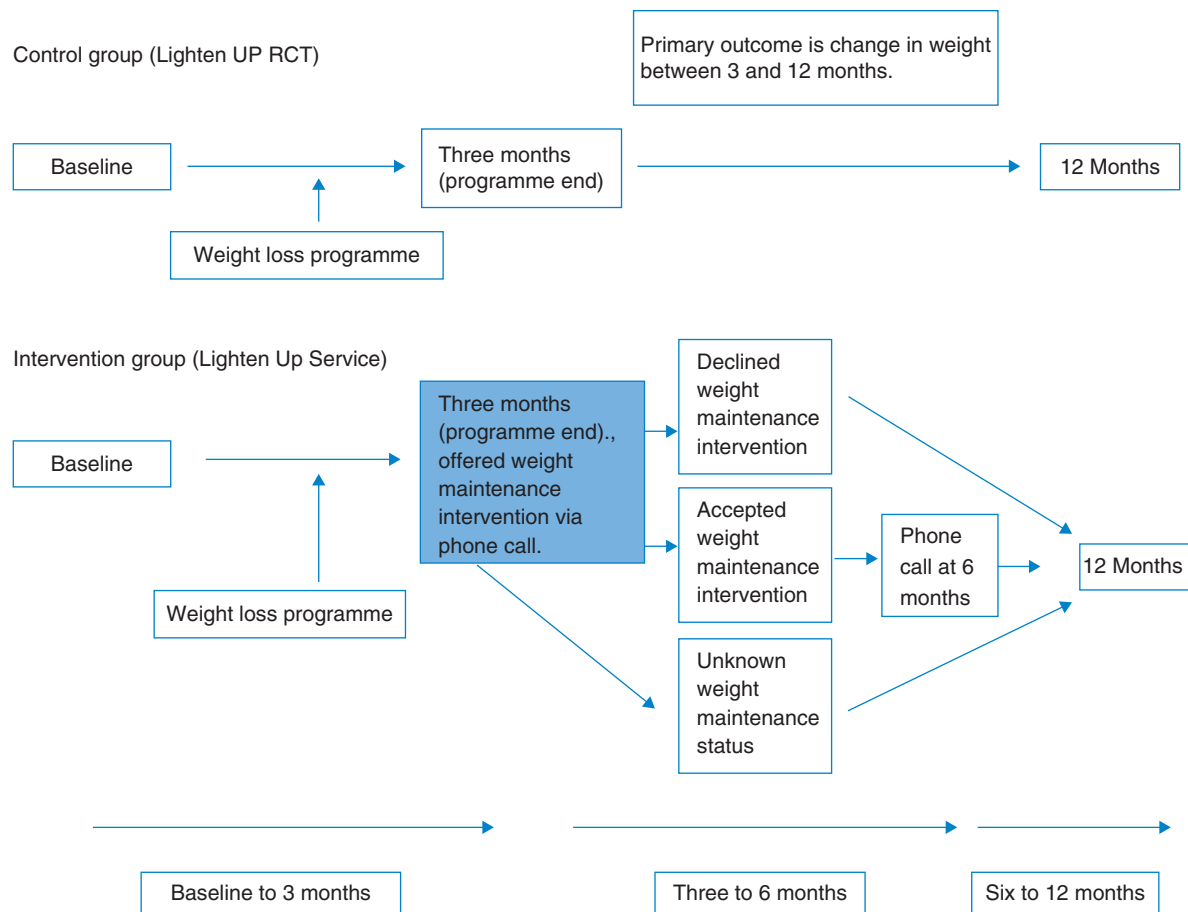


Fig. 1 Study design.

weight maintenance intervention. The weight maintenance intervention was developed by SB PCT based on preliminary evidence^{1,3} supporting the usefulness of self-monitoring for weight management. Participants who accepted were asked if they owned a set of weighing scales; if not, they were sent a voucher to obtain a free set from a local pharmacy. All participants who accepted the intervention were sent a maintenance pack that consisted of a weight record card, a hints/tips booklet about weight management and the Eat Well Plate¹⁶. Participants were instructed to weigh themselves weekly and record this on the card. The call centre staff phoned participants 3 months later (at 6 months from baseline) to encourage regular self-weighing. Call centre staff did not offer opinions or undertake any motivational interviewing, they listened, offered positive reinforcement, encouragement and passed on factual information. The call centre was staffed by two employees trained in call centre management systems and customer relations, but not nutrition or weight management. The main aim of intervention components was to encourage and facilitate regular self-weighing.

Data analysis

Imputation of missing weight data

All trials suffer from loss to follow-up and this is particularly common in weight management trials, where participants who fail to lose weight are reluctant to declare or show this. We imputed missing data to preserve the intention to treat (ITT) principle, but our imputation was conservative. Data for the control group (Lighten Up RCT) was provided by the investigators and routine data for the intervention group (Lighten Up Service) was provided by SB PCT. As the intention was to offer the weight maintenance intervention to all participants, an ITT approach was used with imputed missing data. Missing data at 3 months were imputed by subtracting the average weight loss achieved in those who were followed up for each weight loss treatment from baseline weight. This was the most conservative approach to use because it results in the greatest weight loss between baseline and 3 months and allows the possibility that more weight could be regained between 3 and 12 months. Wing *et al.*⁸ have previously used the formula of adding 0.3 kg per month for missing weight

data, this was used to impute missing weights at 12 months in the present study.

Analyses

All analyses were conducted using SPSS version 18.¹⁷ Baseline differences between the arms were examined by comparing frequency distributions of categorical variables and means of continuous variables. We checked the data fitted the assumptions of the regression models. The primary analysis was conducted using the ITT principle using imputed missing weight data. We repeated the analysis confined to participants where weight was reported. Linear regression was used to determine the mean difference in weight change (3–12 months) between the group given the weight maintenance intervention and the group that was not, using both ITT and per protocol analyses. In the ITT analysis the mean weight change from 3 to 12 months was compared for the groups offered and not offered the weight maintenance programme. Not everyone offered the weight maintenance programme accepted it and in the per protocol analysis mean differences in the weight change between the participants who accepted the intervention and the group not offered the weight maintenance intervention was examined. Age, gender, baseline BMI, weight loss treatment, ethnicity, IMD, amount of weight loss (baseline to 3 months) and occupation were included as covariates. All continuous variables were mean centred and all categorical variables split into binary dummy variables.

It is possible that some weight loss treatments may provide participants with more effective tools to manage their weight than others. If so, the effectiveness of the subsequent weight maintenance intervention may depend upon the type of weight loss treatment received. This was tested by including multiplicative interaction terms between receiving the weight maintenance intervention and type of weight loss treatment. Likewise, it seems likely that the weight maintenance intervention may be more effective for people who have lost most weight as they are at greatest risk of weight regain. We created a dummy variable indicating whether or not participants had lost at least 5 kg in the weight loss treatment and then a multiplicative interaction term with whether or not participants were offered the weight maintenance intervention.

Results

The groups were generally similar on all baseline characteristics assessed prior to the start of the weight loss intervention. There was a higher proportion of females in the intervention group (Table 1). After baseline there was a small difference in the balance of characteristics between the weight maintenance intervention and the control group. The intervention group,

who as part of the service during the initial 3-month weight loss were able to choose their treatment and a higher percentage, chose Slimming World (28 versus 23.4%) and Weight Watchers (41.5 versus 26.8%) than were allocated to these in the control group.

Enrolment for the weight maintenance programme occurred 3 months after the start of the weight loss treatment. At that point, 55% of the intervention group had been followed up and 60.3% of the control group had been followed up. At 12-month follow-up, 62% of the intervention group had been followed up and 82.7% of the control group (Fig. 2).

The mean weight losses between 0 and 3 months in the intervention and control groups was 4.9 kg (SD 3.3) and 4.4 kg (SD 4.1), respectively, meaning a slightly higher weight loss in the group offered the weight maintenance programme, probably because in choosing treatments, they chose a commercial provider more often than the NHS group, which was less effective. There were 3290 participants in the intervention group and of these, 900 (97%) were followed up and included in the per protocol analyses as they accepted the maintenance intervention.

Primary analyses

In the ITT analysis using imputed data, both groups regained weight between the end of the weight loss treatment and 12-month follow-up. However, on average the weight maintenance group regained 1.23 kg and the control group regained 1.83 kg. There was a significant difference of 0.68 kg (about one-third of weight regain) between control and intervention groups, from 3- to 12-month follow-up, after adjustment for covariates (Table 2). When using data on only those participants followed up, the mean difference after adjustment between the groups was larger at 1.67 kg; the intervention group lost a further 1.10 kg compared with the control group, who on average, regained 0.68 kg. Adjusting for covariates did not substantially alter the results.

Per protocol analysis

The per protocol analysis compared participants who accepted the weight maintenance intervention to the control group not offered it. Using imputed data the control group on average regained 1.83 kg and the intervention acceptors lost 1.39 kg. After adjusting for covariates there was a mean difference of 2.96 kg between the control group and those who accepted the maintenance intervention (intervention acceptors; Table 2). Using data only on those followed up, the mean difference was 1.93 kg between the control and intervention acceptors who regained 0.68 kg and lost 1.51 kg, respectively. Adjusting for covariates did not change the results.

Table 1 Baseline characteristics of participants

Variable	All participants, n (%)	Control group (trial), n (%)	Intervention group (service), n (%)	Accepted maintenance intervention, n (%)
Number	3768 (100)	478 (13)	3290 (87)	900/3290 (27)
Gender				
Male	589 (15.6)	153 (32.2)	436 (13.3)	129 (14.3)
Female	3179 (84.4)	325 (68.0)	2854 (86.7)	771 (85.7)
Ethnicity				
White	3185 (84.5)	424 (88.7)	2761 (83.9)	767 (85.2)
Mixed	96 (2.5)	11 (2.3)	85 (2.6)	19 (2.1)
Asian	178 (4.7)	8 (1.7)	170 (5.2)	42 (4.7)
Black	276 (7.3)	32 (6.7)	244 (7.4)	64 (7.1)
Other	31 (0.8)	3 (0.6)	28 (0.9)	8 (0.9)
Weight loss programme				
NHS group-based programme	325 (8.6)	113 (23.6)	212 (6.4)	49 (5.4)
Rosemary Conley	916 (24.3)	125 (26.2)	791 (24.0)	186 (20.7)
Slimming World	1033 (27.4)	112 (23.4)	921 (28.0)	280 (31.1)
Weight Watchers	1494 (39.6)	128 (26.8)	1366 (41.5)	385 (42.8)
Mean age in years (SD)	50.9 (14.88)	51.14 (14.73)	49.93 (14.90)	53.16 (14.66)
Baseline BMI (SD)	34.8 (5.5)	33.7 (3.6)	35.1 (5.7)	35.5 (6.3)
3-month BMI (SD)	33.2 (5.4)	32.2 (3.7)	33.3 (5.6)	33.5 (6.1)
Weight loss 0–3 months (kg)	−4.8 (3.4)	−4.4 (4.1)	−4.9 (3.3)	−5.5 (3.9)
IMD quartile				
0 (most deprived)	1947 (51.7)	244 (51.0)	1703 (51.8)	428 (47.6)
1	1316 (34.9)	169 (35.4)	1147 (34.9)	351 (39.0)
2	449 (11.9)	57 (11.9)	392 (11.9)	110 (12.2)
3 (least deprived)	55 (1.5)	7 (1.5)	48 (1.5)	11 (1.2)
Occupation				
Employed	1916 (50.8)	271 (56.7)	1645 (50.0)	401 (44.6)
Not working/unemployed	865 (23)	66 (13.8)	799 (24.3)	205 (22.8)
Retired	854 (22.7)	103 (21.5)	751 (22.8)	282 (31.3)
Unable to code	109 (2.9)	21 (4.4)	88 (2.7)	12 (1.3)

Effect modification by weight loss treatment received and initial weight loss

Those who lost more weight may have benefited most from the weight maintenance intervention; however, there was no significant effect ($T = -0.95$, $df = 1$, $P = 0.34$). If some weight loss treatments prepared participants to be better able to manage their weight after treatment than others, then the weight maintenance intervention may have been less effective for those participants. There was no evidence to support this suggestion ($F = 1.99$, $df = 3$, $P = 0.11$).

Discussion

Main findings of the study

We used routine data from a service that was implemented within primary care and found participants who were offered

a weight maintenance intervention after completing a weight loss treatment, regained less weight. The intervention prevented about a third of the weight regain seen in the controls. This finding did not depend on the amount of weight lost between baseline and 3 months or the type of weight loss treatment received. The per protocol analysis showed the difference in weight regain between those in the intervention group who accepted the intervention, and the control group was substantial at 2.96 kg. The intervention seemed to prevent all weight regain and indeed led to further small weight loss.

What is already known on this topic

These results are similar to two maintenance RCTs that investigated the effect of self-weighing.^{10,12} The first report

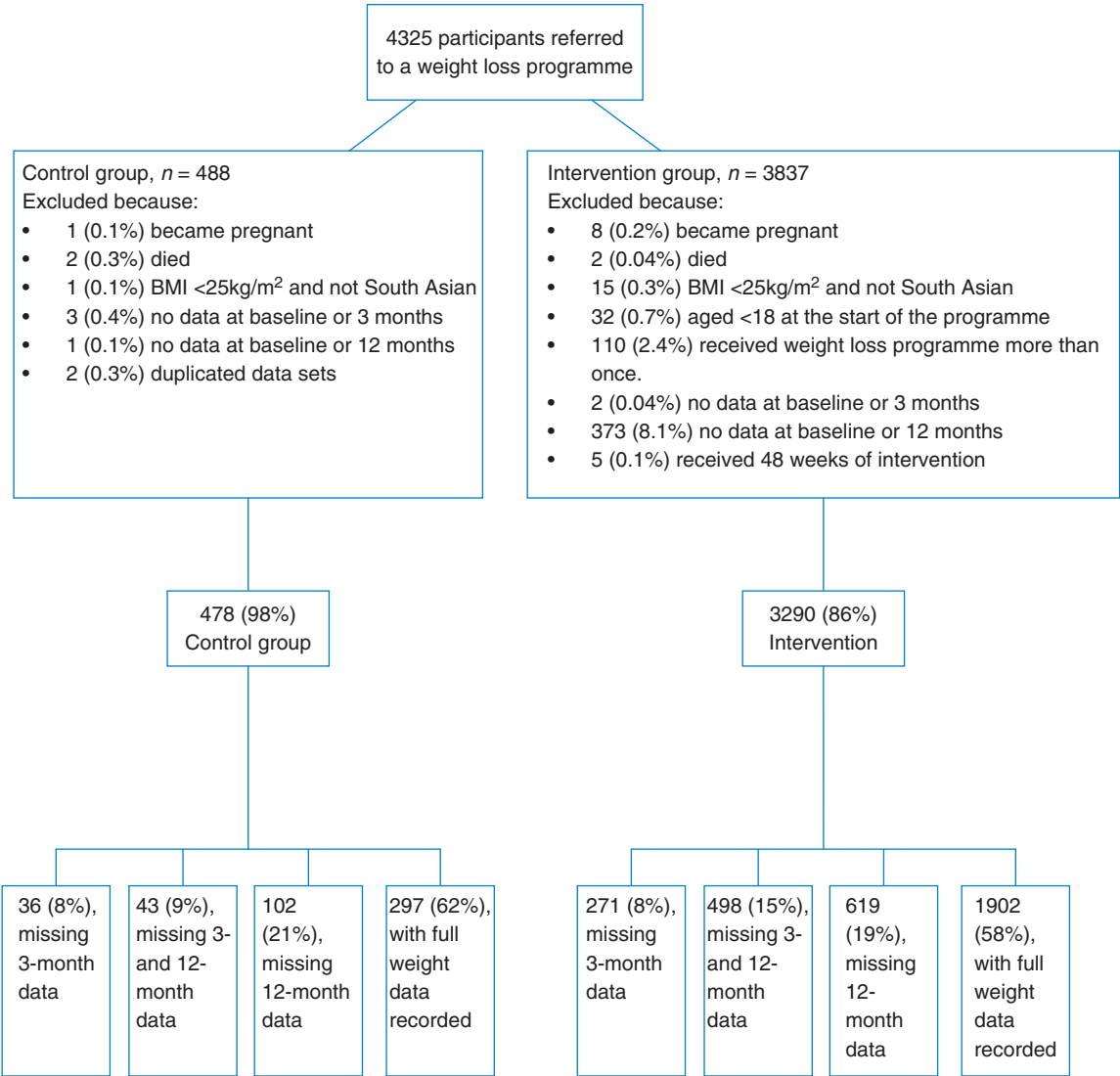


Fig. 2 Exclusions and participant flow for control and intervention groups.

included two experiments ($n = 75$).¹⁰ In both intervention groups participants weighed themselves daily and emailed their weight daily to the researchers who gave feedback via email. Ten weeks after enrolment, those who completed the trial in experiment one weighed a mean of 3.1 kg less than the controls and in experiment two they weighed 2.8 kg less. In the second RCT ($n = 89$) all participants attended an initial behaviour therapy weight loss programme and the intervention group were instructed to weigh themselves and record this four times per day.¹² At the end of the behaviour therapy programme (6.5 months from baseline) there was no significant difference between groups in the mean weight change. After the behavioural therapy the self-weighing intervention group was instructed to continue to record their weight and at 2-year follow-up had regained significantly less weight than

controls (mean difference = 7.1 kg). The studies described here and which have typically used per protocol have reported positive findings. The mean differences in these studies are much larger than reported in our ITT analyses (0.68 kg). Our ITT analysis may provide a more realistic indication of the magnitude of preventable weight regain that can be expected from an intervention aiming to get participants to regularly weigh themselves during weight maintenance.

What this study adds

Many people with weight problems take action to lose weight but almost invariably put it back on. If we have a range of simple evidence-based self-help strategies that may prevent weight regain we can encourage participants to use these.

Table 2 Mean weight change and difference in weight change between the control and intervention groups

	Intervention group weight change between 3 and 12 months, kg (SD)	Control group weight change between 3 and 12 months, kg (SD)	Mean difference in weight change from 3 to 12 months, kg (95% CI)	
	Unadjusted	Unadjusted	Unadjusted	Adjusted
Imputed weight	1.23 (5.8) (n = 3290)	1.83 (5.5) (n = 478)	-0.60 (-1.15, -0.05)*	-0.68 (-1.24, -0.12)**
Reported weight	-1.10 (5.9) (n = 1902)	0.68 (6.1) (n = 297)	-1.79 (-2.51, -1.07)**	-1.67 (-2.40, -0.93)**
Mean difference between the control group and those who accepted the weight maintenance package				
Imputed weight	-1.39 (6.1) (n = 900)	1.83 (5.5) (n = 478)	-3.21 (-3.87, -2.55)**	-2.96 (3.67, -2.25)**
Reported weight	-1.51 (6.1) (n = 876)	0.68 (6.1) (n = 297)	-2.19 (-2.99, -1.38)**	-1.93 (-2.79, -1.08)**

*Significant values <0.05.

**Significant values <0.001.

Natural experiments such as this one can help identify possible strategies and this study has highlighted that an intervention including encouragement to regularly self-weigh, a hints/tips leaflet and phone prompts, might be one of these strategies.

Eighty-seven per cent of participants were from the poorest 40% of neighbourhoods and 16% were from minority ethnic groups. This implies that a simple intervention strategy can effect behaviour change in a population that is difficult to engage. Missing data were accounted for using conservative assumptions which are likely to overestimate the weight regain. This is important because it is likely that people who have done well on a weight loss treatment are more likely to report on their weight than people who have regained weight. This is most likely in the intervention group who were sent weighing scales and a record card and who were telephoned twice and encouraged to continue their efforts on weight maintenance. Hence, why our primary analyses used ITT as people who joined the maintenance programme may have been more motivated to lose weight.

Limitations of this study

This natural experiment meant participants were allocated to the groups based on the time at which their GPs started using the Lighten Up service. It is possible that there was some systematic difference between participants who were enrolled later and received the intervention and those enrolled earlier allocated to control. Our data do show some differences in gender balance and ethnicity between arms. The most important predictor of weight change at 12 months was amount of weight lost initially and participants in the intervention group lost somewhat more (0.5 kg) initially and would have greater

potential for weight regain, biasing the results in favour of the controls at 12 months. Although we adjusted for these variables, we could not adjust for unmeasured differences between the groups, but there is no clear reason to assume this was such an imbalance. Future research should utilize an RCT methodology to address this question further. Whilst the study included a very large sample size the results need to be considered in the context of the rates of 40% loss to follow-up at 12 months. However, we used a conservative method to impute missing weight data but this may have overestimated the weight regained as the regain was much higher for those with imputed weight data (Table 2).

The main difference between the groups is that control groups were weighed at 3 and 12 months while due to the number of participants in the intervention group self-reported weight at 12 months was used. People typically underestimate their weight when asked to self report which may have led to bias that favoured the intervention group. Importantly however, the Lighten Up RCT found those who self-reported their weight had a smaller weight loss (0.6 versus 0.8 kg) than those objectively measured between 3- and 12-month follow-up.¹⁴ We have used conservative methods to minimize bias but we cannot control for the difference in the measurement of weight and is a limitation of this research. Lastly, self-weighing frequency was not assessed and this would be an important feature of future studies.

Conclusion

A pragmatic weight maintenance intervention that encourages regular self-weighing as well as a hints/tips booklet and

phone prompts may reduce weight regain after intentional weight loss. Our findings imply that minimal instruction to weigh oneself-regularly together with providing the tools to do so, such as a record card to initiate the behaviour, could usefully become part of routine follow-up for people who have been through a weight loss programme.

Ethical approval

National Research Ethics Committee London—Surrey borders (12/LO/0111) granted ethical approval (proportionate review).

Authors' contribution

K.J., A.D., P.A., J.D. designed the Lighten Up trial and it was coordinated by A.L. J.D. designed and managed the Lighten Up service. C.D.M. and A.D. drafted the paper with additional input from P.A., K.J. and A.L. C.D.M. and P.A. conducted the statistical analyses. All authors have read and agreed the final version of the manuscript. A.D. is the guarantor. The trial registration for the control group is ISRCTN25072883 and the intervention group is based on secondary data from an ongoing service.

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University of Birmingham acted as sponsor and had no role in the design, conduct or reporting of the study.

Data sharing

Additional data can be obtained from the corresponding author for the purposes of secondary research. Source of funding: RSF/NIHR PhD studentship for Claire Madigan.

Conflict of interest

P.A. has received hospitality from Weight Watchers on one occasion and A.L. twice; J.D. was employed by the funding organization and managed the service.

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