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A low-burden, self-weighing intervention to prevent weight gain in adults with obesity who do not enroll in comprehensive treatment

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Abstract

Background: For individuals who are eligible but unlikely to join comprehensive weight loss programs, a low burden self-weighing intervention may be a more acceptable approach to weight management.

Methods: This was a single-arm feasibility trial of a 12-month self-weighing intervention. Participants were healthcare patients with a BMI ≥25 kg/m^2 with a weight-related comorbidity or a BMI >30 kg/m^2 who reported lack of interest in joining a comprehensive weight loss program, or did not enroll in a comprehensive program after being provided program information. In the self-weighing intervention, participants were asked to weigh themselves daily on a cellular connected scale and were sent text messages every other week with tailored weight change feedback, including messages encouraging use of comprehensive programs if weight gain occurred.

Results: Of 86 eligible patients, 39 enrolled (45.3%) in the self-weighing intervention. Self-weighing occurred on average 4.6 days/week (SD = 1.4). At 12 months, 12 participants (30.8%) lost ≥3% baseline weight, 11 (28.2%) experienced weight stability (±3% baseline), 6 (15.4%) gained ≥3% of baseline weight, and 10 (25.6%) did not have available weight data to evaluate. Three participants reported joining a weight loss program during the intervention (7.7%). Participants reported high intervention satisfaction in quantitative ratings (4.1 of 5), and qualitative interviews identified areas of satisfaction (e.g., timing and content of text messages) and areas for improvement (e.g., increasing personalization of text messages).

Conclusion: A low-burden self-weighing intervention can reach adults with overweight/obesity who would be unlikely to engage in comprehensive weight loss programs; the efficacy of this intervention for preventing weight gain should be further evaluated in a randomized trial.

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KEYWORDS
interventions, obesity, recruitment, self-weighing, treatment initiation, weight management

1 | INTRODUCTION

Although over 90% of US adults with obesity express a desire to lose weight, only about 10% take part in any weight loss program each year.[1] Comprehensive behavioral weight loss programs produce weight loss and health improvements,[2,3] but cost and accessibility can serve as barriers to program enrollment. These barriers are reduced for some due to increased access to low-cost or no cost programs in community settings,[4,5] workplaces,[6,7] and health care facilities[8]; however, even when programs are offered for low or no cost, most individuals with obesity or overweight do not participate.[8,9] Beyond cost and accessibility, numerous additional barriers to engagement in comprehensive behavioral weight loss programs exist. The significant time commitment that many of these programs demand is a commonly cited concern.[10,11] Additionally, some individuals have low motivation to change their diet and physical activity.[10,12,13] For example, in one study, 32% of participants said they did not want to carry out program recommendations[13] and a qualitative analysis revealed a theme of being prescribed certain foods as a barrier to program use.[12] Moreover, some individuals decline programs because they think didactic sessions are unnecessary, believing that they already know what they need to do to manage their weight.[12,14] Others object to attending group sessions.[12,15]

Less burdensome intervention approaches may be more appealing to individuals with barriers to comprehensive program use. One such approach is an intervention focused on daily self-weighing in the absence of specific recommendations related to dietary intake and physical activity (or any other weight-related behaviors such as the self-monitoring of these behaviors). Two studies have focused on self-weighing (both focused on weight gain prevention) that did not explicitly prescribe changing diet and physical activity or include additional components focused on these areas.[16,17] Both of these trials showed attenuated weight gain in self-weighing conditions compared with controls; however, both included participants that were primarily college students and in the "normal" weight range. Thus, additional research is needed to determine the effectiveness of a low burden self-weighing program among adults with overweight/obesity who are unlikely to enroll in a comprehensive weight loss program.

For individuals who are engaging in regular self-weighing, the experience of observing weight gain may increase motivation to regulate their weight, including potential reassessment of the benefits and barriers to joining a weight loss program. Joining a comprehensive program in response to small weight gains can support long-term weight maintenance.[18]

Thus, we theorize that a low burden self-weighing intervention may reach patients who otherwise may not receive support for weight management, and can contribute to weight maintenance through two potential pathways. First, regular self-weighing may help prevent weight gain; second, regular self-weighing will improve awareness of weight gain if it occurs, and motivate future enrollment in a comprehensive weight management intervention, supporting long-term weight maintenance. As a first step to evaluate these possible benefits, the current study was a pilot trial of a low-burden self-weighing intervention (named STEADY) designed to enhance weight management in adults with overweight and a weight-related comorbidity or obesity who either (1) denied interest in enrolling in a comprehensive weight loss program or (2) did not enroll in a comprehensive weight loss program within a month after being provided information about available programs. The co-primary aims of this pilot study were to evaluate (1) the acceptability of the STEADY self-weighing intervention in this population and (2) the feasibility of study procedures (e.g., assessing whether recruitment and retention could support a larger and fully powered clinical trial). Qualitative data collection was used to characterize the range of experience individuals had with the intervention in order to inform future intervention refinement.

2 | MATERIALS AND METHODS

2.1 | Study design and procedures

Using pre-specified criteria for age (18–70 years old) and BMI/comorbidity criteria (25–30 kg/m^2 with a weight-related comorbidity of diabetes, pre-diabetes, hypertension, hyperlipidemia, or sleep apnea; or BMI >30 kg/m^2), we conducted a clinical and administrative database search of patients in a large academic health science center in the Southeastern US who had a health care appointment in the prior month. Patients identified in this search were sent an email and mailed a letter inviting them to complete a paid ($10) "health behaviors" survey that had no explicit mention of weight or treatment (in order to avoid recruiting a sample already motivated to engage in weight loss treatment). Prior to completing the health behavior survey, patients completed an online screening questionnaire and were excluded if, according to self-report, they did not meet age or BMI/comorbidity criteria. Additionally, patients were excluded if they weighed >170 kg (due to upper weight limitations on a study provided smart scale) or if they reported sending less than one text message per month. Patients were also excluded if they reported current enrollment in a comprehensive weight loss treatment, if they weighed themselves more than 5 times per week in the prior month, or if they had a history of eating disorders or certain health conditions that would require closer monitoring of weight (e.g., congestive heart failure, recent cardiovascular event, ongoing cancer treatment).

Patients eligible at screening were invited to complete a health behavior survey that included evaluation of additional eligibility criteria for inclusion in the STEADY feasibility trial. Specifically, patients were presented with a description of a generic 16-week comprehensive weight loss program and asked if they would join this program if it were free to them (full text of the program description is available at https://osf.io/9vqpt). If they indicated that they would not join such a program, they were eligible for the STEADY trial and offered enrollment in STEADY. A second pathway to eligibility occurred for patients who indicated that they were interested in a comprehensive program. Immediately after completing the health behavior survey, these patients were provided information about several commercial programs (WW, Noom) and a low cost community-based program (Taking Off Pounds Sensibly; about $35 yearly membership fee and $5 monthly fee[19]) to ensure that they were aware of options with a range of formats and costs. They were then re-contacted 1 month later to determine if they had initiated any comprehensive weight loss program; if they had not, they were considered eligible for the STEADY trial and offered enrollment in STEADY. Of note, the second criterion was only applied after 2 months of screening using only the first criterion, when the team became concerned that recruitment would not be sufficient to assess intervention acceptability (as only 4 of the first 12 patients screened were eligible based on the first criterion, and all 4 declined the self-weighing intervention).

When invited to join the trial, STEADY was described as an intervention focused on preventing weight gain through daily self-weighing. Additionally, during the consent process, they were informed that they may be given the option to obtain information on additional resources for weight management.

2.2 | Intervention

The STEADY intervention was a remotely delivered, low burden self-weighing intervention. Participants who enrolled in the STEADY intervention were mailed a smart scale (BodyTrace, Inc) that sent weights directly to researchers via the cellular network and were instructed to weigh themselves daily. Participants were also sent a text message with a link to a study website that included written instructions about how to set up their scale, best practices for self-weighing (e.g., to weigh themselves first thing in the morning after voiding, to keep the scale in a prominent location), suggestions for managing scale challenges (e.g., moving scale if there are connectivity issues), and guidance on how to interpret changes in weight (e.g., looking at overall trends vs. focusing on day-to-day variations).

Participants were sent a text message every other week throughout the 12-month study. Message content was determined based on self-weighing frequency and two weight change values: (1) weight change from baseline to the most recent weight, and (2) weight change in the prior 2 weeks. Participants were considered weight stable if they had not gained or lost ≥1.5% of their weight over the prior 2 weeks or ≥3% since baseline, and were given messages encouraging continued self-weighing (e.g., "It looks like you are keeping your weight stable. Great job! Continue to weigh yourself daily!"). If they had lost weight in the prior 2 weeks (≥1.5%; regardless of weight change since baseline) or had lost weight since baseline (≥3.0%) and were stable in the prior 2 weeks, they were given messages acknowledging weight loss and encouraging ongoing self-weighing. If participants had gained ≥1.5% over the prior 2 weeks (regardless of weight change since baseline) or had gained ≥3.0% body weight since baseline and were stable in the prior 2 weeks, they were sent a text message noting that they had gained weight and offering advice (e.g., "Our data show that your weight has gone up in the past few weeks. Are you interested in learning about tools that can help you with avoiding weight gain or losing weight?") along with a hyperlink to a REDCap survey that asked questions in order to provide automated, tailored feedback on strategies for weight management. If they followed this hyperlink, they were asked to select if they were interested in avoiding weight gain or losing weight. If they reported interest in avoiding weight gain, they were encouraged to use an app (MyFitnessPal) to track their food intake. If they selected instead that they desired weight loss, they were asked further questions to tailor feedback, including their past challenges or barriers to weight loss, their preference for online versus in-person support for weight loss, and their experience with well-known weight loss programs. Depending on their response to these questions, they were given a recommendation to consider enrolling in either Noom, Weight Watchers/WW, or TOPS and given information about each of these programs, including hyperlinks to websites providing information about how to enroll (similar to that provided during general health survey).

A different schema was used to determine text message content when fewer than 10 days with weights were documented over the 14 days check-in period. In particular, participants were sent a text message encouraging greater engagement with self-weighing if they had fewer than 10 days with weights documented and either (1) had no weights in the 5 days prior to check-in, or (2) had an available weight in the 5 days prior to check-in that showed that they were weight stable. If participants with fewer than 10 weights did have an available weight in the 5 days prior and were not weight stable, a weight loss or weight gain message (described above) was delivered, according to weight change pattern. Although participants were asked to weigh daily, a threshold of 10 weights was selected by the research team to provide some flexibility for missed days. On the first time a text message was sent encouraging more self-weighing (and up to monthly thereafter), the message included a hyperlink to a REDCap webpage that encouraged participants to tell us what was getting in the way of self-weighing by selecting from a list of common challenges (including scale issues). After indicating specific challenges, participants were given automated tailored suggestions for overcoming these challenges. Participants were contacted by the study team to solve problems if scale challenges were noted. If a participant continued to self-weight for fewer than 10 days each week for four additional weeks, they were sent a text message that indicated that they may have regained weight and linked them to resources for weight management, identical to content sent to participants showing weight gain. For each scenario, several versions of messages were

developed to avoid repetition (all messages used in the STEADY intervention are available at https://osf.io/p95jk/).

2.3 | Measures

Weight data was obtained via the study-provided BodyTrace smart scales, which have been demonstrated to be highly concordant with body weight measured via in-person assessments.[20–22] At first weigh-in, participants were asked to step on and off the scale three times in succession in order to ensure a stable weight, and the two closest weights were averaged for a baseline weight.[23] Additional weight measures used in analyses were based on participants' regular self-directed self-weighing; participants were not given any specific instructions or incentives for weights after baseline.

Patients completed online survey assessments at baseline, 3 months, and 12 months. Intervention acceptability was assessed via online REDCap surveys at the 12-month assessments, including participant ratings of satisfaction with various aspects of the program (e.g., the smart scale, the text messages, study overall), with response options ranging from strongly disagree[1] to strongly agree.[5] Additionally, patient engagement with self-weighing, automatically recorded by the smart scale, was used as an indicator of intervention acceptability (each day that at least one weight was recorded was coded as a day that self-weighing occurred). Trial feasibility was assessed by tracking recruitment data, including the proportion of patients who enrolled compared to those who were deemed eligible via the health behaviors survey, and retention at the 3- and 12-month assessments.

At baseline, 3-month, and 12-month assessments, participants completed several additional items and measures in order to evaluate the feasibility of assessment procedures for a future trial and characterize the sample. These measures included a single-item measure assessing motivation to lose weight (developed by the research team for this study), ranging from 0 (not at all motivated) to 10 (extremely motivated), and another single-item measure assessing engagement in physical activity (the Leisure-Time Activity Categorical Item [L-CAT][24,25]). At each assessment, participants also completed validated measures of depression symptomology (the Center for Epidemiological Studies Depression; CES-D)[26], their experience of weight stigma (Modified Weight Bias Internalization Scale; WBIS),[27,28] and eating disorder symptomology (Eating Disorder Examination Questionnaire; EDEQ).[29,30] At the 3- and 12-month assessments, participants were also asked if they had engaged in several weight management strategies, including if they had monitored their food intake since the study started or if they had joined a weight loss program. Participants were paid $10 for completing each follow-up survey.

2.4 | Qualitative data collection

To inform interpretation of the quantitative results in relation to feasibility and acceptability and to better understand patient experience with the intervention, a sub-sample of participants was invited to complete an individual interview at the end of the study. Selection of participants was aimed at obtaining representation of the range of outcomes with regard to weight changes and engagement with self-weighing. In structured individual interviews guided by a moderation script and conducted by the lead author (MAM), participants were queried about their experience with the study, including strategies and challenges with using the scale, reasons for absence of self-weighing, effects of self-weighing, and perceptions of text messages (for full moderator script, see https://osf.io/p95jk/). Interviews were audio recorded and transcribed verbatim.

2.5 | Data analysis

Variables of interest were described as frequencies or means and standard deviations, as appropriate. Given the goals of this pilot and the corresponding small sample size, inferential statistical testing was not conducted.[31] We sought to recruit approximately 40 participants based on commonly accepted pilot study sample size guidance[32] and our own judgment about how many participants would be necessary to meet study feasibility/acceptability goals. Frequency of self-weighing was calculated over the 12-month study period and over each quarter of the intervention as a mean number of days with weights per week. If participants had a weight measured in the final 30 days of the intervention, their initial weight and final weight were used to calculate weight change from baseline, using only complete cases. Participants were asked to avoid having other individuals use the scale; however, weight data were still screened for outliers. Weights that were implausibly low (<40 kg) were removed, and then a scatterplot of each participant's weights over time was visually inspected to identify (and remove) data points that deviated from the trend line in a non-plausible way. Weight change was categorized as weight stable (±3% baseline weight), weight gain (≥3% baseline weight gain), or weight loss (≥3% baseline weight loss)[33] across the 12 months. Survey data were analyzed using SPSS version 28.0.0.0, and weight data were analyzed using R version 4.3.0.

Qualitative data were analyzed using conventional content analyses.[34] Two coders (MAM and MD) independently coded six interviews, reconciling codes after every one to two interviews coded. One coder independently coded the remaining manuscripts. Codes were grouped based on themes closely mirroring the content of the moderation script. Interviews were conducted until informational redundancy was met, which was obtained after analyzing 12 interviews. Human subjects' approval was obtained from the University of Florida Institutional Review Board.

3 | RESULTS

3.1 | Trial recruitment and retention

Screening for the general health survey was completed by 401 patients, and 129 completed the general health survey. Of those, 85

were eligible for STEADY and 39 enrolled (45.8% of eligible). These 39 enrollees included 6 participants who were eligible for STEADY based on reporting lack of interest in a comprehensive weight loss program during the general health survey (out of 32 in this group who were offered enrollment), and 33 participants who had expressed interest in a comprehensive program during the general survey, but had not enrolled in a program when contacted one month later (out of 55 in this group who were offered enrollment).[35] See Table 1 for sample characteristics of enrolled participants (participant flow figure available at https://osf.io/p95jk). Additional information about participant enrollment, including predictors of enrollment in STEADY, has been published elsewhere.[35] Survey assessments were completed by 37 (94.9%) and 34 (87.2%) participants at 3 and 12 months, respectively.

3.2 | Self-weighing engagement

Self-weighing engagement is summarized in Figure 1. On average, participants weighed themselves 4.6 days each week (SD = 1.4) during the 12-month intervention. The mean number of days with documented weights in each 3-month quarter of the study was 4.9 (SD = 1.2), 4.2 (SD = 1.7), 4.0 (SD = 1.6), and 4.2 (SD = 1.7), respectively.

Occasional challenges with the study scales were noted. Staff typically learned about problems when patients received text messages encouraging more frequent self-weighing, and replied to those messages indicating challenges with the scale. Staff also occasionally learned when reaching participants on the phone. Issues included connectivity problems, patients reporting that study records did not appear to capture all the weigh-ins they completed, and scale batteries dying. When participants noted issues with the scale, study staff aimed to try to solve the problems, for example, by encouraging movement of the scale to a new location with better cellular reception.

3.3 | Engagement with weight loss efforts

Based on either a period of weight gain or low self-weighing frequency, 35 participants (89.7%) received content aiming to engage them with weight loss or weight gain prevention resources at least once during the intervention, and 23 (65.7% of those texted) engaged with this content by going to the webpage linked in the text message sent. Of those who engaged, 19 indicated interest in losing weight at least one time during the study, and thus were given recommendations to join a comprehensive weight loss program. Five indicated interest in avoiding weight gain (including two participants who at another time indicated interest in weight loss) and were thus given recommendations to use an online self-monitoring tool. At the 12 months survey, three participants indicated that they had joined a structured weight loss program over the prior 12 months (Noom:

TABLE 1 Baseline characteristics of study participants.

	Total sample (n = 39)
Age, years, *M* (SD)	44.7 (13.1)
Weight, kg, *M* (SD)	101.6 (19.7)
BMI (kg/m^2), *M* (SD)	34.7 (5.8)
Weight category, *n* (%)	
Overweight	5 (12.8%)
Obese	34 (87.2%)
Gender,[a] *n* (%)	
Women	19 (48.7)
Men	20 (51.3)
Education, *n* (%)	
Less than bachelors	14 (35.9)
Bachelors or higher	25 (64.1)
Race, *n* (%)	
Black	6 (15.3)
White	24 (61.5)
Asian	6 (15.3)
Multi-racial	3 (7.7)
Ethnicity	
Hispanic/Latino	5 (12.8)
Non-Hispanic	34 (87.2)
Marital Status, *n* (%)	
Married or living with partner	24 (61.5)
Not married or living with partner	14 (35.9)
Other	1 (2.6)
Work status, *n* (%)	
Not employed full-time	13 (33.3)
Employed full-time	24 (61.5)
Prefer not to answer	2 (5.1)
Presence of obesity comorbidities, *n* (%)	
Has comorbidity[b]	28 (71.8)
Does not have comorbidity	11 (28.2)
Ever attended weight loss program, *n* (%)	
Yes	10 (25.6)
No	29 (74.4)
Tried to lose weight in past year, *n* (%)	
Yes	31 (79.5)
No	8 (20.5)

[a]Participants were asked to report "gender." Participants were given options other than listed here, but no participants selected other options.

[b]Comorbidities included diabetes, pre-diabetes, hypertension, hyperlipidemia, or sleep apnea.

n = 2, WW: n = 1) and 11 participants reported that they had recorded their food intake over the course of the intervention.

At 3 months, 86.5% (32/37) of participants said they were trying to lose weight, and a similar proportion (85.7%, 30/35) reported trying to lose weight at 12 months. On the single-item measure of weight loss motivation, a small decline was observed from baseline to 12 months (M = 7.8 to M = 6.9; see Table 2). Levels of physical activity at baseline, 3 and 12 months are presented in Table 2.

3.4 | Weight change

At 12 months, 12 participants (30.8%) lost ≥3% baseline weight, 11 (28.2%) experienced weight stability (±3% baseline), 6 (15.4%) gained ≥3% of baseline weight, and 10 (25.6%) did not have available weight data to evaluate. The mean weight change across the 29 participants with available weight data was −1.4% (SD = 5.1). Separated by gender, men (n = 15) lost 1.6% (SD = 4.5) and women (N = 14) lost 1.1% (SD = 5.9) of baseline body weight. Considering weight change as it relates to enrollment pathways, among participants who were eligible based on declining interest in comprehensive treatment during the health survey (n = 4), mean weight loss was 3.3% (SD = 5.3) while for those who had interest in treatment at baseline but did not enroll one month later (n = 25, mean weight loss was 1.0% (SD = 5.1).

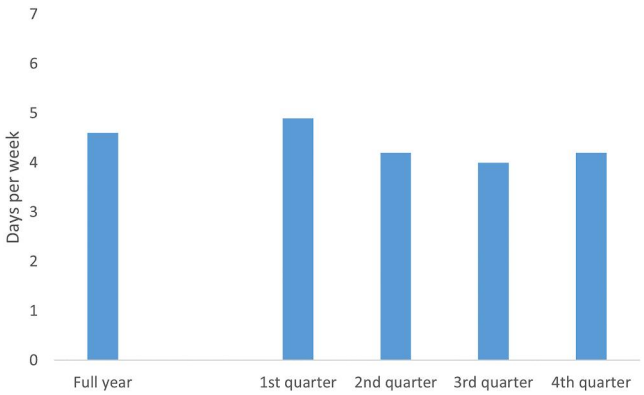

FIGURE 1 Mean days per week of self-weighing.

3.5 | Psychosocial outcomes

Table 2 shows values for depressive symptoms, internalized weight stigma, and eating disorder symptomology over the course of this study.

3.6 | Intervention acceptability

On items focused on various components of satisfaction, scores suggested that patient satisfaction with the program was moderate to high (see Table 3). The mean response on an overall satisfaction item was 4.1 out of 5, with 76% of participants agreeing or strongly agreeing that they were satisfied. In responses to questions related to the text messages, most participants agreed or strongly agreed that they were easy to understand (97%) and were helpful (65%). Most participants also agreed or strongly agreed that the instructions on how to use the scale were clear (91%). Technical difficulties with the scale were endorsed by 26% of participants.

3.7 | Qualitative data

Qualitative interviews were used to examine how participants responded to and engaged in the intervention (see https://osf.io/p95jk/ for full list of codes). When asked about their reasons for joining the program, some participants reported that their interest in joining STEADY stemmed from a desire for weight loss or increased

TABLE 2 Characteristics across study assessment time periods.

	Possible range	Baseline	3 months	12 months
Physical activity (LCAT), *n* (%)				
Inactive		8 (20.5)	5(12.8)	3 (7.7)
Light, 1–2x/week		16 (41.0)	14 (35.9)	15 (38.5)
Moderate, 3x/week		7 (17.9)	10 (25.6)	8 (20.5)
Moderate, ≥5x/week		6 (15.4)	3 (7.7)	7 (17.9)
Vigorous, 3x/week		2 (5.1)	1 (2.6)	0 (0)
Vigorous, ≥5x/week		0 (0)	4 (10.3)	1 (2.6)
Weight loss motivation, *M* (SD)	1–10	7.78 (2.21)	7.54 (2.21)	6.94 (2.82)
Depression symptomology level (CES-D), *M* (SD)	0–30	10.33 (6.76)	10.00 (7.41)	9.38 (7.02)
Internalized weight stigma (WBIS), *M* (SD)	1–6	3.18 (1.20)	3.16 (1.24)	3.10 (1.24)
Eating disorder symptomology (EDEQ) total, *M* (SD)	0–6	2.05 (1.20)	2.02 (1.16)	1.91 (1.28)

Note: Baseline n = 39, 3 months n = 36, 12 months n = 34.

TABLE 3 Intervention satisfaction at 12 months.[a]

	Means	Frequencies		
	M (SD)	Disagree or strongly disagree, *n* (%)	Neutral, *n* (%)	Agree or strongly agree, *n* (%)
Experience with smart scale				
The instructions about using the smart scale provided at the beginning of the program were easy to understand.	4.5 (0.9)	1 (2.9)	2 (5.9)	31 (91.2)
I had technical difficulties with my scale.	2.3 (1.3)	21 (61.8)	4 (11.8)	9 (26.5)
I had difficulty remembering to weigh myself.	2.2 (1.1)	21 (61.8)	9 (26.5)	4 (11.8)
I was not motivated to weigh myself.	2.2 (1.2)	23 (67.6)	7 (20.6)	4 (11.8)
Experience with intervention text messages				
The text messages sent as part of the program were easy to understand.	4.5 (0.6)	0 (0)	1 (2.9)	33 (97.1)
The text messages sent were helpful.	3.7 (1.1)	4 (11.8)	8 (23.5)	22 (64.7)
Text messages were sent too often.	2.5 (1.1)	22 (64.7)	7 (20.6)	5 (14.7)
Text messages were not sent often enough.	2.5 (1.0)	17 (50)	13 (38.2)	4 (11.8)
General satisfaction				
Overall, I am satisfied with this program.	4.1 (1.0)	2 (5.9)	6 (17.6)	26 (76.5)
The program helped me to avoid weight gain.	3.6 (1.2)	6 (17.6)	6 (17.6)	22 (64.7)
I would recommend this program to a friend.	3.9 (1.0)	2 (5.9)	9 (26.5)	23 (67.6)

[a]*N* = 34, due to non-response from 5 participants. All items had a possible range of one to five with 1-strongly disagree, 3-neither agree nor disagree, and 5-strongly agree.

self-awareness. Participants also reported being drawn to STEADY because it offered something simpler than other programs, and because they had failed with other approaches.

Participants identified numerous strategies for adhering to regular self-weighing. These included weighing at a consistent time of day, keeping scales in a visible location, and allowing self-weighing to become a habit. Reasons for failing to weigh regularly included the occurrence of specific events, such as negative life events, travel, or change in routine. Other reasons included the scale being placed in a poor location, believing they had finished the study, and not prioritizing self-weighing. Participants also identified challenges to using the scale, including weights not being recorded, receiving error codes during self-weighing, obtaining inaccurate readings, or their scale battery dying.

Participants shared their thoughts about the text messages sent as part of the intervention. Many participants had positive views on the text messages, describing them as helpful reminders to self-weigh. They liked that the content of the messages was positive and upbeat, that it acknowledged both long- and short-term weight changes, and that it helped them feel a sense of accountability. They also identified some negative aspects of their experience with the text messages, including that the messages sometimes felt redundant or repetitive and lacked a human element (i.e., they sensed that messages were automated). Technical issues such as not receiving the text were also reported. Some participants indicated they would have preferred more frequent texts. One participant reported that the message inappropriately presented weight loss as positive when weight loss was due to being ill, and one participant who responded negatively to self-weighing found the messages upsetting, as they reminded him of his struggle with weight.

Another area that participants were asked about was their response to observing weight gains, losses, and stability. In response to weight gain, participants reported feeling frustrated or upset, reflecting on causes of the gain, and taking action in response to gain, including making dietary changes, ongoing self-weighing, and, in some cases, abandoning weight control efforts. In response to weight loss, participants reported feeling excited, becoming more motivated to manage their weight, and taking actions such as continuing to do what they were doing. In some cases, they reported lessening weight control efforts in response to weight loss. In response to a weight stable outcome, participants reported being more motivated, taking action, such as increasing exercise or dietary change, and emotional experiences that varied from mildly disappointed to content.

Participants also reflected more generally on the experience of self-weighing, and reported that it led to increased awareness of their weight and causes of their weight change, as well as increased accountability to self. Participants also reported that self-weighing increased motivation to achieve their dietary goals, dietary change (including changing specific foods), and increased exercise. Some participants reported that the intervention helped them avoid weight gain and improve health outcomes. While most participants did not indicate that self-weighing had broad effects on their mood, one

participant reported that self-weighing helped them overcome weight related distress, while another patient reported that it had worsened his mental health (this was same patient who was distressed in response to text messages, noted previously). General thoughts on the intervention included that it fit well in their lifestyle (e.g. because it was easy to do). Some participants suggested improvements, typically involving provision of additional content such as dietary/physical activity guidance or more extensive involvement from an interventionist.

4 | DISCUSSION

In this pilot study, trial feasibility and intervention acceptability were evaluated for a low burden, remotely delivered self-weighing intervention, specifically focusing on individuals unlikely to enroll in a comprehensive weight loss program. Overall, results suggest that this intervention approach has the potential to reach and benefit this population, although changes to study design and the intervention may be warranted prior to further testing.

Engagement with an intervention is an important indicator of acceptability and intervention potential. Our results show that nearly half of those offered the intervention enrolled, suggesting the potential reach of this approach. Once enrolled, the level of adherence to self-weighing (4.6 days with weights observed per week on average) was consistent with or slightly lower than that seen in other studies prescribing daily self-weighing (e.g., Bertz observed 5.0 and 5.8 times per week at 6 and 12 months).[17,36,37] Some participants reported that their data were not being registered at times, therefore these numbers may be an underestimation of engagement.[38]

One of the goals of this intervention, unique from other self-weighing interventions, was to drive engagement with other tools for weight loss among individuals who appeared to be gaining weight. This approach may facilitate long-term weight maintenance by addressing and reversing weight gain before it progresses further. The STEADY intervention was only modestly successful at achieving this goal, with three people initiating a weight loss program during the study out of the 23 who received encouragement to use these programs. Future interventions targeting this population might develop additional strategies to improve the uptake of comprehensive weight loss programs among those who gain weight. For example, content could incorporate motivational interviewing approaches to enhance motivation to use these programs or more extensively tailor information to address barriers to engagement.[39,40]

On average, participants lost 1.4% of their baseline weight at 12 months and nearly 80% of those with available weight had no weight gain; however, the weight change outcomes for this study must be interpreted with caution, given the small sample size and absence of a control group. A larger study with a control group is a critical next step to evaluate overall intervention effectiveness in relation to the prevention of weight gain, as it is unknown what the weight trajectory would have been for this sample without intervention.

While the text messages were well liked overall, some participants reported feeling that the text message feedback felt automated and impersonal. One strategy that could increase self-weighing engagement in a future intervention is to provide feedback in a way that feels more personal. By creating more of a relationship with an interventionist who may endorse the text messages (even if partially or fully automated), participants may engage more, consistent with the supportive accountability model.[41,42] Additionally, technical challenges with the scale were noted. Some of these can be prevented in future studies (e.g., by providing extra batteries; by improving instructions), while others are more difficult to address (e.g., connectivity issues)[43] Participants' insights into their reasons for success or lack of success in self-weighing offer guidance for improving self-weighing frequency in the future. For example, changes in routine and travel were reported as a reason for getting out of the habit of self-weighing. Potentially, this could be addressed by greater outreach to people who are not meeting self-weighing goals, such as phone calls (vs. sending automated text messages, as done in the current study).

This pilot trial also offered an important opportunity to test the feasibility of the study protocol to inform a future, fully powered randomized controlled trial of the STEADY intervention. Recruitment goals were met, with almost half of the eligible participants enrolling in the trial. However, to reach this goal, eligibility criteria were expanded from those who declared a lack of interest in comprehensive weight loss programs to those who initially indicated interest in participating in a comprehensive weight loss program but had not enrolled 1 month later. Retention for the 3- and 12-month surveys delivered via REDCap was high, well over the 80% threshold often considered successful in weight loss trials, suggesting that this online data capture method was feasible and would be appropriate to use in a larger trial. In terms of weight outcome data, 29 participants (74.4% of enrollees) had a useable weight measurement in the final month of the study. In this trial, participants were not paid for weight measurements; including this strategy in a future trial may increase outcome measurement.

The negative experience of one participant (who reported that the program contributed to a decline in his mental health) highlights the importance of monitoring for potential adverse effects, even in studies such as this where patients with eating disorder histories are excluded. Future iterations of self-weighing interventions could address this by building in regular assessments of psychological outcomes to the intervention and developing a plan to address individuals who respond negatively. While most past studies do not show negative mental health effects from self-weighing interventions,[44–47] most of these studies have tested interventions with more active content than the current low-intensity intervention.

This trial has several limitations. Use of dietary self-monitoring was measured during follow-up surveys, but not at baseline, so change could not be assessed. Participants had to first agree to take a survey to be part of this study, and thus the population reflects those willing to engage in survey research. While scale challenges were documented systematically through survey items, we did not

systematically record scale challenges reported directly to study staff. Additionally, this study provided information and encouragement to use comprehensive weight loss programs, but the cost of these programs was not covered by the study; while this may decrease engagement with these programs compared to if costs were covered, the current approach mimics the situation in many real world settings. This study was relatively short for considering weight gain prevention; in a future trial, the intervention should be studied for greater than 1 year. Finally, the sample population predominantly included individuals identifying as non-Hispanic White, and full data on the number of people sent the invitation to the survey was not available.

Several strengths of this study are notable. Qualitative interviews were conducted to gain an in-depth understanding of patient experience with the intervention. The study was fully remote, enabling wider participation than might have otherwise been possible. Another strength of this study is that our sample was just over 50% men, distinguishing it from the typical enrollment seen in weight loss trials and community interventions that enroll women predominantly.[48,49] In our study from this data set, there was no statistically significant difference in enrollment in STEADY between men and women among those offered STEADY.[35] Considering also that men in the current study lost a similar amount of weight as women, these results suggest that for the many men who are not inclined to enroll in a comprehensive program, a lower burden self-weighing approach offers promise.

In conclusion, this feasibility trial showed that a significant portion of adults with obesity who do not enroll in a comprehensive weight loss program would enroll in a low burden, remotely delivered self-weighing program. Further, the extent of self-weighing observed was similar to past studies not specifically targeting those unlikely to enroll in a comprehensive program. Acceptability data and weight outcome data point to the potential of this approach for reaching a population who may otherwise be susceptible to weight gain, though further intervention refinement and testing is warranted.

AUTHOR CONTRIBUTIONS

Megan A. McVay conceived the study. Megan A. McVay, Montserrat Carrera Seoane, Melinda Rajoria, Marissa Dye, Natalie Marshall, Sofia Muenyi, Kellie B. Scotti, and Jaime Ruiz contributed to the conduct of the study. Megan A. McVay, Melinda Rajoria, Kellie B. Scotti, and Anas Alkanderi contributed to data analyses. Megan A. McVay, Corrine I. Voils, and Kathryn M. Ross contributed to interpreting the study results. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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CONFLICT OF INTEREST STATEMENT

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DATA AVAILABILITY STATEMENT

Data from this article are available by request to the corresponding author.

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