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Impact of newer self-monitoring technology and brief phone-based intervention on weight loss: a randomized pilot study

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Abstract

Objective—Despite the proliferation of newer self-monitoring technology (e.g., activity monitors and smartphone apps), their impact on weight loss outside of structured in-person behavioral intervention is unknown.

Methods—A randomized, controlled pilot study was conducted to examine efficacy of self-monitoring technology, with and without phone-based intervention, on 6-month weight loss in adults with overweight and obesity. Eighty participants were randomized to receive standard self-monitoring tools (ST, n=26), technology-based self-monitoring tools (TECH, n=27), or technology-based tools combined with phone-based intervention (TECH+PHONE, n=27). All participants attended one introductory weight loss session and completed assessments at baseline, 3 months, and 6 months.

Results—Weight loss from baseline to 6 months differed significantly between groups $p=.042$; there was a trend for TECH+PHONE ($-6.4\pm1.2\text{kg}$) to lose more weight than ST ($-1.3\pm1.2\text{kg}$); weight loss in TECH ($-4.1\pm1.4\text{kg}$) was between ST and TECH+PHONE. Fewer ST (15%) achieved 5% weight losses compared to TECH and TECH+PHONE (44%), $p=.039$. Adherence to self-monitoring caloric intake was higher in TECH+PHONE than TECH or ST, $p<.05$.

Conclusion—These results suggest use of newer self-monitoring technology plus brief phone-based intervention improves adherence and weight loss compared to traditional self-monitoring tools. Further research should determine cost-effectiveness of adding phone-based intervention when providing self-monitoring technology.

Keywords

Obesity; Monitoring; Overweight; Weight Loss; Intervention

Introduction

Self-monitoring of weight and weight-related behaviors (e.g., caloric intake and physical activity) has been considered a “cornerstone” of behavioral weight management treatment,

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and higher adherence to self-monitoring has been associated with improved weight loss within these interventions.^{1,2} Newer, technology-based tools that make self-monitoring of weight and weight-related behaviors easier offers promise for improving adherence to self-monitoring and thus weight loss. These new technologies include websites and smartphone applications (apps) that allow individuals to track caloric intake throughout the day, along with activity-monitors and “smart” scales that synch with these websites/apps. When combined, these technologies allow individuals to view their weight, caloric intake, and physical activity data in one location.

While previous research has demonstrated that other technology-based approaches (e.g., the use of text messages³ or email counseling⁴) offer promise for lowering the cost (and thus potentially increasing the reach) of weight loss treatments, newer self-monitoring tools offer key advantages. One advantage has been their commercial popularity; there was an 80% increase in shipments of activity monitors in 2015 (compared to 2014)⁵ and Fitbit (a popular commercial provider of newer self-monitoring technologies) alone reported selling 3.9 million devices in the first quarter of 2015.⁶ Further, these tools have additional advantages over previous technologies as they simplify self-monitoring while also incorporating key behavioral weight management treatment components: they allow individuals to set goals and compare their self-monitoring data to these goals, and they provide immediate reinforcement for reaching short and long-term goals (e.g., phone notifications, positive messages in emails, and “badges” functioning as visual reminders of goals met).

Research on the use of these newer technologies within traditional behavioral weight management programs has demonstrated improved adherence and weight loss outcomes compared to traditional self-monitoring tools.^{7–10} This research, however, has often examined one specific type of technology; no studies to date have investigated the impact of a total technology “package” that combines the self-monitoring of weight, caloric intake, and physical activity within one system and includes behavioral strategies that extend beyond self-monitoring (such as goal setting, feedback, and reinforcement). Further, little research has evaluated the impact of these tools outside of in-person behavioral weight-management programs. Given that these tools are typically used by consumers without additional intervention, it is important to determine whether these newer technologies used alone, or with additional contact, are effective for improving adherence and weight control.

One type of additional contact that might be offered with newer technologies is phone-based intervention. Previous research has demonstrated that brief telephone counseling can lead to clinically-significant weight losses in adults with overweight and obesity.^{11,12} Since weight losses achieved with phone counseling are comparable to those obtained with in-person weight management groups,¹³ phone-based interventions have been described as a cost-effective approach to treatment delivery.^{11,12,14} In a weight gain prevention trial, an intervention combining a smartphone app and phone-based telephone counseling led to greater improvements in eating and activity behavior and small weight losses compared to a minimal-contact educational control.¹⁵

The current study investigated the impact of newer self-monitoring technology (compared to traditional self-monitoring tools), provided with and without a brief phone-based

intervention, on weight loss in adults with overweight and obesity. We hypothesized that participants who received newer self-monitoring technology along with a phone-based weight loss intervention (TECH+PHONE) would lose more weight (and be more likely to achieve a clinically-significant weight loss) than participants who were given the newer technology alone (with no interventionist contact; TECH) and that both of these groups would lose more weight than those given traditional weight management tools (i.e., a printed calorie book, written food records, and a standard pedometer; ST) and no interventionist contact. We further hypothesized that adherence to self-monitoring would be higher in TECH+PHONE compared to TECH, and in TECH compared to ST.

Method

Participants

Eligibility criteria included age between 18 and 70 years, body mass indices (BMIs) between 27 and 40 kg/m², and access to a computer and WiFi at home. Participants who indicated a history or current diagnosis of diabetes, cardiovascular disease, or difficulty with physical activity were required to obtain written approval from their physician to participate. Participants were excluded if they reported any of the following: physical limitations that prevented them from walking 1/4 mile without stopping, current participation in another weight loss program or taking weight loss medication, current pregnancy or plans to become pregnant during the study period, having a medical condition that would contraindicate weight loss (e.g., uncontrolled Type 2 diabetes, uncontrolled hypertension, or history of coronary heart disease) or if they failed to attend scheduled study orientation or baseline assessment visits.

Recruitment

Participants were recruited through advertisements in local newspapers, flyers hung on public bulletin boards, and on the study center's website. Advertisements were based on standard behavioral weight loss program advertisements used at our research center and did not mention the use of technology. Individuals who contacted the research center in response to advertisements were given basic information about the study and asked to complete an online pre-screen. Potential participants who met initial eligibility criteria were then scheduled to attend an in-person orientation visit, where the study was explained in detail, ample time was spent discussing clinical equipoise (and the pros and cons of randomization into each group), and written informed consent was obtained. Participants knew that two conditions would be asked to track weight-related behaviors using newer technology but the system used was not revealed except to the TECH and TECH+PHONE participants, post-randomization. Randomization occurred following the completion of baseline measures, and was revealed to participants at their "Weight Loss 101" session. Randomization was conducted via computer using a 1:1:1 allocation.

Intervention

All three groups attended one in-person "Weight Loss 101" session, at which participants were given general weight loss guidelines, including calorie goals of 1200 to 1500 kcal per day (based on baseline weight) and recommendations to consume < 30% of calories each

day from fat. Participants were encouraged to gradually increase engagement in moderate-intensity physical activity (e.g., brisk walking) to 250 minutes per week, and to aim for 10,000 steps per day. The three groups were then taught to use the self-monitoring tools associated with their condition (described in detail below).

ST Condition—Participants in the ST condition were provided with self-monitoring tools previously used in other weight loss interventions at our research center. Specifically, participants were given a calorie reference book, a pedometer to monitor daily step counts, and a body weight scale if the participant did not have one at home. Participants were also provided with 24 weeks' worth of paper self-monitoring booklets to use to track their caloric intake, physical activity, and weight each day. Participants were not given explicit instructions to avoid using technology to self-monitor their behaviors. No further intervention contact was provided after this initial visit.

TECH Condition—Participants randomized to the TECH condition were given a Fitbit Zip activity monitor, a Fitbit Aria smart scale, and were asked to track their caloric intake using the Fitbit smartphone app or [Fitbit.com](https://www.fitbit.com) website. The Fitbit Zip attached to participants' waistband and kept track of steps walked and calories burned throughout the day. The calorie tracking system used by the Fitbit app and [Fitbit.com](https://www.fitbit.com) allowed individuals to search for foods consumed, to log foods throughout the day, and provided immediate updates regarding progress toward calorie goals (including total calories eaten per meal and a running total of calories eaten during the day). The Fitbit Aria scale automatically synced participants' weights with the Fitbit app and [Fitbit.com](https://www.fitbit.com) dashboard, and both which displayed graphics to let participants track their weight change over time. A key feature in this system involved the ability to receive feedback continually; participants could see their calorie totals updated live throughout the day, and could see graphs of their caloric intake, physical activity (as steps and minutes of moderate and vigorous-intensity physical activity), and weight over time. Further, Fitbit set weekly email to users including average steps per day, average calories consumed, and summaries of goal progress during the previous week. Participants were asked to track their caloric intake, physical activity, and body weight each day using the provided tools. No further intervention contact was provided after this initial visit.

TECH+PHONE Condition—Participants randomized to the TECH+PHONE condition received the same materials as TECH, but additionally received phone-based interventionist contact over the 6 month intervention. Fourteen structured phone calls (using a manualized protocol) were provided with gradually descending frequency (8 weekly, 4 bi-weekly, and 2 monthly phone calls were scheduled). Prior to each call, interventionists reviewed the participant's prior week of self-monitoring data through a central dashboard (developed by Small Steps Labs, San Diego, CA). Interventionists included the first author, a clinical psychologist, and a dietician employed by our center, both trained in the delivery of standard behavioral weight loss treatment. Calls were scheduled for 10–15 minutes and focused on standard behavioral weight loss techniques, including goal setting,¹¹ problem solving,¹⁷ stimulus control,¹⁸ seeking social support,¹⁹ and relapse prevention.²⁰

Measures

Assessments occurred at baseline, Month 3, and Month 6. Height and weight were measured by trained research assistants blinded to treatment condition, in light indoor clothing and with shoes removed. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer, and body weight was measured to the nearest 0.1 kg using a calibrated digital scale. Height and weight were measured twice at each visit and measurements were averaged. Demographic characteristics were assessed using a self-report questionnaire. Participants were a website link to complete the study questionnaires online (via RedCAP).²¹

Adherence—Participant adherence was measured in two ways. First, adherence was measured objectively in TECH and TECH+PHONE as the number of days that participants completed food records through the Fitbit app or website, wore the Fitbit to track activity, and used the smartscale to track their weight. As this information was only available on two groups (an objective measure of self-monitoring adherence was not available in the ST group), we further used items from the Weight Control Strategies Scale,²² a self-report measure which asked participants how frequently they engaged in certain weight-related behaviors (e.g., keeping records of type/amounts of food consumed, keeping records of minutes of exercise, and self-weighing; items #3, #16, and #23, respectively). This measure has demonstrated validity and sensitivity to change over the course of weight management intervention.²² As an exploratory analysis, we additionally examined scores for the “Self-Monitoring Strategies” index of the WCSS by group, to facilitate comparison to previous post-treatment group means in the literature. Contamination (defined as use of newer self-monitoring technology to track behavior in the ST condition) was tracked using a self-report questionnaire, and all participants were asked at Month 6 whether they had joined any other weight management programs.

Statistical Analyses

All analyses were conducted using SAS version 9.4 for Windows.²³ Using data from a previous technology-based weight management study,⁸ a power analysis was conducted using SAS, with an alpha of .05 and a power of .80. This analysis suggested a sample size of 84 would be needed to reach an actual power of .809 for testing the overall model for the primary aim.

Baseline differences between groups were assessed using ANOVAs. An intent-to-treat approach was used, with multiple imputation (SAS PROC MI) used to handle missing weight data. For secondary outcomes, missing data were handled with maximum likelihood estimation under a missing-at-random approach, using SAS PROC MIXED.

The primary aim, investigating differences in weight change from baseline to Month 6 between conditions was examined using a repeated-measures ANOVA (with the model including weights at baseline, Month 3 and Month 6). Planned contrasts were then used to conduct comparisons of the three conditions on weight loss from baseline to 6 months. Bonferroni corrections (adjusted $\alpha = .017$) were used to prevent inflated potential for Type I errors. We examined differences between groups in terms of achievement of clinically-

significant weight losses ($\geq 5\%$ from baseline weight at 6 months) using a chi-square analysis; participants who did not return at follow-up were assumed to have not met the 5% cut-off.

The secondary aim, assessing adherence to self-monitoring by group, was assessed two ways. First, differences in objective self-monitoring data between TECH and TECH+PHONE were assessed using t-tests. Changes from baseline to Month 6 in WCSS self-monitoring adherence items by group were assessed using longitudinal mixed effects models (SAS PROC MIXED), with Bonferroni corrections used when interpreting significant group by time interactions (adjusted $\alpha = .017$).

Results

Of the 293 individuals who reported interest in the study, 80 were randomized to one of three groups: 26 to ST, 27 to TECH, and 27 to TECH+PHONE (see Figure 1). At baseline, participants were an average of ($\pm$ SD) 51.1 ± 11.7 years old and had BMIs of 33.0 ± 3.4 kg/m²; 86% self-identified as female, and 84% self-identified as non-Hispanic White. There were no differences at baseline between groups in terms of sex, race/ethnicity, income level, or education (see Table 1). There was a significant difference between groups in terms of age, $F(2,77) = 3.93$, $p = .024$, such that participants in the TECH group were significantly younger than participants in the ST group, $p < .05$. In terms of retention, 72 of the 80 participants completed the 6 month assessments (90%), with no difference by group (ST = 88.5%, TECH = 92.6%, TECH+PHONE = 88.9%), $p > .05$. Two ST participants reported also using a technology-based self-monitoring tool during the intervention period; in keeping with the intent-to-treat protocol these participants were included within the ST group for all analyses. No participants enrolled in the study reported joining any other weight management programs during the study period.

Primary Aim: Change in weight over time by group

Results demonstrated a significant difference in weight change over time by group, $F(4,77) = 2.62$, $p = .042$ (see Figure 2). Specifically, from baseline to Month 6, TECH+PHONE participants had trends for greater weight losses (mean change $\pm$ SE = -6.40 ± 1.17 kg; $7.37 \pm 1.29\%$) than ST (-1.28 ± 1.19 kg; $-1.22 \pm 1.32\%$), $t(50) = -1.85$, $p = .035$; weight losses in the TECH group (-4.04 ± 1.37 kg; $-4.35 \pm 1.29\%$) did not differ significantly from either the TECH+PHONE or SC groups, $ps > .05$.

Clinically-significant weight loss—At 6 months, there were significant differences in achievement of clinically-significant weight loss (defined as weight loss $\geq 5\%$) by group, $\chi^2(2) = 6.51$, $p = .039$, such that participants in the TECH (44.4%) and TECH+PHONE (44.4%) conditions were significantly more likely to meet this cut-off compared to ST (15.4%). Investigating differences in weight change distribution by group (see Figure 3), over 65% of participants in ST and 52% of TECH participants lost less than 3% or gained weight, whereas this occurred in less than 30% of TECH+PHONE, $\chi^2(2) = 6.93$, $p = .031$.

Secondary Aim: Adherence

Intervention call completion—TECH+PHONE participants completed an average of 13.0 ± 2.9 calls (range = 1 to 14 calls, 85.2% of participants completed all scheduled calls). Call length ranged from 9 to 52 minutes, with an average time of 22.9 ± 8.3 minutes. Interventionists completed an average of 2.2 call attempts (i.e. calls that were not completed due to failure to reach participant via phone) per participant.

Self-monitoring—Using objective data, participants in the TECH+PHONE group tracked caloric intake significantly more days than TECH participants (see Table 2). The difference adherence to weight monitoring also approached significance, with trends toward greater monitoring in TECH+PHONE. Moreover, 81.5% of TECH+PHONE monitored their intake on 50% or more of the 180 days, compared to 48.2% of TECH, *Fisher's exact* $p = .021$. Likewise, a greater proportion of TECH+PHONE participants monitored their weight on over 50% of days (88.9% vs. 59.3, respectively, *Fisher's exact* $p = .028$). The two groups did not differ in adherence to physical activity tracking, $p > .05$. Across both TECH and TECH+PHONE, percent weight change from baseline to Month 6 weight was significantly associated with adherence to monitoring caloric intake 6, $r = -0.48$, $p < .001$, and weight, $r = -0.42$, $p = .002$; however, there was no association between adherence to wearing the activity monitor and weight change, $p = .085$. The same pattern of results was demonstrated when investigating these associations within group.

Using data from the WCSS, there was a significant difference between groups in change in self-report of self-monitoring of caloric intake and weight from baseline to Month 6 (see Table 2) such that participants in the ST group reported smaller increases in self-monitoring compared to TECH and TECH+PHONE participants (see Table 2); however, there was no difference between groups in adherence to self-monitoring of physical activity. Mean ($\pm$ SE) subscale scores on the WCSS "Self-Monitoring Strategies" index at Month 6 were 1.45 ± 0.48 for ST, 2.11 ± 0.20 for TECH, and 2.52 for TECH+PHONE.

Discussion

The current study demonstrated that a weight loss program combining newer technology and phone contact produced an average weight loss of 6.4 kg (7.4% from baseline) at six months. Moreover, 44% of TECH+PHONE participants achieved a clinically-significant weight loss. Although the TECH+PHONE group received only one face-to-face session and 14 phone calls, this level of contact when combined with newer self-monitoring technologies produced weight losses that were comparable to those from higher intensity weight loss programs (such as those including weekly group meetings for 24 weeks).¹

The TECH program, which used the same self-monitoring technology as TECH+PHONE, but which provided technology without additional interventionist contact, produced weight losses of 4.0 kg (4.4%) at six months, which did not differ significantly from TECH +PHONE or ST. Moreover, an identical proportion of TECH and TECH+PHONE achieved a clinically-significant weight loss. While these results suggest beneficial effects of TECH alone, the finding that 51% of participants in TECH did poorly (either gained weight or lost

>3 kg over the 6 months; see Figure 3) suggests that the effects of TECH were more variable across participants, with about half doing very well but half achieving minimal success.

Rates of adherence to self-monitoring in ST (mean of 1.45 on the “Self-Monitoring Strategies” index of the WCSS) were similar to post-treatment means found after participants completed a traditional behavioral weight loss trial (mean at post-treatment: 1.43);²² means for both TECH and TECH+PHONE were higher than reported in this prior study, at 2.11 and 2.52, respectively. Further, although adherence to self-monitoring of physical activity was high in both TECH and TECH+PHONE, the level of adherence to calorie and weight monitoring were higher in TECH+PHONE than in TECH. Taken together, these results suggest that the addition of phone-based intervention may increase adherence to self-monitoring, which may help more individuals lose more weight compared to the provision of technology alone.

The current study has several important limitations. First, sample size was limited (by design, as this was a pilot trial); these results support a larger randomized clinical trial assessing the impact of newer self-monitoring technology on weight loss. Second, participants were followed only for six months, and thus we were unable to assess longer-term weight loss and weight loss maintenance between groups. Long-term maintenance of weight loss is a considerable challenge²⁰ and thus future studies should include longer follow-up. Finally, participants in the current study were predominately white and female; results may not generalize to other population groups. Future studies should increase recruitment of men and individuals from racial/ethnic minority groups.

Strengths of the current study include the prospective, randomized design, high participant retention, objective measures of adherence to self-monitoring in the two TECH groups, and the timely investigation of tools that currently exist in the commercial market but have little evidence for efficacy. The current study represents the first attempt to investigate the impact of an entire package of commercially-available technology-based self-monitoring tools on weight loss in individuals who are overweight and obese. Importantly, we were able to compare the use of standard behavioral self-monitoring tools directly with newer technology-based self-monitoring tools outside of the context of standard in-person behavioral weight management programs.

The results from the current study support previous studies that have found that newer self-monitoring technologies can promote greater adherence to self-monitoring and improve weight loss outcome compared to standard self-monitoring tools.^{7–10} Since an equal proportion of TECH and TECH+PHONE participants achieved clinically significant weight losses, future studies should investigate the cost-effectiveness of combining newer self-monitoring technology with phone intervention compared to the use of technology alone; the additional weight loss experienced by TECH+PHONE may not be sufficient to justify the added costs of a coaching-based intervention. Overall, these results are encouraging on a public-health level, as they demonstrate that lower contact interventions using newer self-monitoring technologies that include key aspects of behavioral weight management interventions may offer an avenue for the widespread dissemination of effective weight loss treatment.

Conclusion

These results demonstrate that newer self-monitoring technology plus brief phone-based intervention can improve adherence to self-monitoring and lead to greater weight losses than traditional paper-based self-monitoring tools. Future research should investigate whether these weight losses can be maintained longer-term, and particularly whether phone-based intervention represents a cost-effective strategy compared to use of newer self-monitoring technology alone.

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What is already known about this subject?

Behavioral weight management treatment is effective for weight loss but costly; newer technologies offer promise for reducing the cost of treatment delivery.

Incorporating newer technologies for self-monitoring weight (“smart” scales), caloric intake (smartphone applications and websites), and physical activity (newer activities monitors) within standard behavioral weight loss treatments leads to improved adherence to self-monitoring and weight loss.

Phone-based weight management interventions have demonstrated efficacy for weight loss in individuals with overweight and obesity.

What does this study add?

Whereas prior studies have evaluated weight loss technology as a component of a standard behavioral treatment program, this was the first study to examine the efficacy of newer technology for weight loss used after only a single session of behavioral weight control, with or without additional interventionist phone contact.

Participants randomized to receive newer self-monitoring technology combined with brief phone-based intervention had significantly higher adherence to self-monitoring and lost more weight than participants randomized to receive traditional self-monitoring tools. Provision of newer self-monitoring tools without additional phone intervention produced outcomes midway between the other two groups.

Increased adherence to the self-monitoring of weight and caloric intake were associated with greater weight loss, and results suggested that adding brief, phone-based intervention increased adherence to self-monitoring compared to the provision of technology alone.

Figure 1.
Participant flow through enrollment, randomization, and follow-up.

Figure 2.
Change in weight (kg, mean [SE]) by intervention group, from baseline to Month 6.

Figure 3.
Distribution of weight losses in ST, TECH, and TECH+PHONE groups.

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Table 1

Baseline characteristics of randomized participants.

	ST n=26		TECH n=27		TECH+PHONE n=27	
	M	SD	M	SD	M	SD
Age	54.23	9.49	46.19	13.53	52.93	10.31
Weight (kg)	91.6	14.54	89.23	15.57	87.1	12.39
	n	%	n	%	n	%
Gender						
Female	22	84.62	24	88.89	23	85.19
Male	4	15.38	3	11.11	4	14.81
Race/Ethnicity						
African American	2	7.69	1	3.7	0	0
Asian	0	0	0	0	0	0
Caucasian	21	80.77	23	85.19	23	85.19
Hispanic	1	3.85	2	7.41	2	7.41
Other/Multiple	2	7.69	1	3.7	2	7.41

Table 2

Adherence to self-monitoring during the intervention, by group.

Adherence	ST (n = 26)		TECH (n=27)		TECH+PHONE (n=27)		p
	M	SE	M	SE	M	SE	
Objectively Measured Adherence [*]							
Days tracked caloric intake (of 180)	-	-	83.70	11.12	126.59	11.11	.009
Days wore Fitbit (of 180)	-	-	137.37	8.82	154.15	8.98	.118
Days self-weighed (of 180)	-	-	101.59	10.92	132.48	10.91	.051
Change in WCSS Item [†]							
"I Kept a Record of the Type and Amount of Food I Ate"	0.88	0.31	1.51	0.31	2.30	0.30	.007
"I Kept a Record of My Minutes of Exercise"	0.97	0.33	1.59	0.32	1.35	0.31	.408
"I Weighed Myself Daily"	1.40	0.34	1.55	0.33	2.80	0.33	.007

^{*} Available for only TECH and TECH+PHONE[†] Scoring: 0 = Never, 4 = Always; Change in scores from baseline to Month 6 are presented