

# Integrating Technology Into Standard Weight Loss Treatment

## A Randomized Controlled Trial

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**Background:** A challenge in intensive obesity treatment is making care scalable. Little is known about whether the outcome of physician-directed weight loss treatment can be improved by adding mobile technology.

**Methods:** We conducted a 2-arm, 12-month study (October 1, 2007, through September 31, 2010). Seventy adults (body mass index  $>25$  and  $\leq 40$  [calculated as weight in kilograms divided by height in meters squared]) were randomly assigned either to standard-of-care group treatment alone (standard group) or to the standard and connective mobile technology system (+mobile group). Participants attended biweekly weight loss groups held by the Veterans Affairs outpatient clinic. The +mobile group was provided personal digital assistants to self-monitor diet and physical activity; they also received biweekly coaching calls for 6 months. Weight was measured at baseline and at 3-, 6-, 9-, and 12-month follow-up.

**Results:** Sixty-nine adults received intervention (mean age, 57.7 years; 85.5% were men). A longitudinal intent-to-treat analysis indicated that the +mobile group lost a

mean of 3.9 kg more (representing 3.1% more weight loss relative to the control group; 95% CI, 2.2-5.5 kg) than the standard group at each postbaseline time point. Compared with the standard group, the +mobile group had significantly greater odds of having lost 5% or more of their baseline weight at each postbaseline time point (odds ratio, 6.5; 95% CI, 2.5-18.6).

**Conclusions:** The addition of a personal digital assistant and telephone coaching can enhance short-term weight loss in combination with an existing system of care. Mobile connective technology holds promise as a scalable mechanism for augmenting the effect of physician-directed weight loss treatment.

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**I**NTENSIVE MULTICOMPONENT BEHAVIORAL treatment produces clinically significant weight loss ( $>5\%$  of initial body weight) in overweight and obese adults.<sup>1,2</sup> The US Preventive Services Task Force recommends intensive behavioral treatment for all obese adults, citing evidence that more contact within the first year produces greater weight loss.<sup>3</sup> Treatment involves behavioral self-management activities, such as setting weight loss goals, self-monitoring, improving diet and physical activity, addressing barriers to change, and strategizing how to maintain lifestyle changes.<sup>4,5</sup>

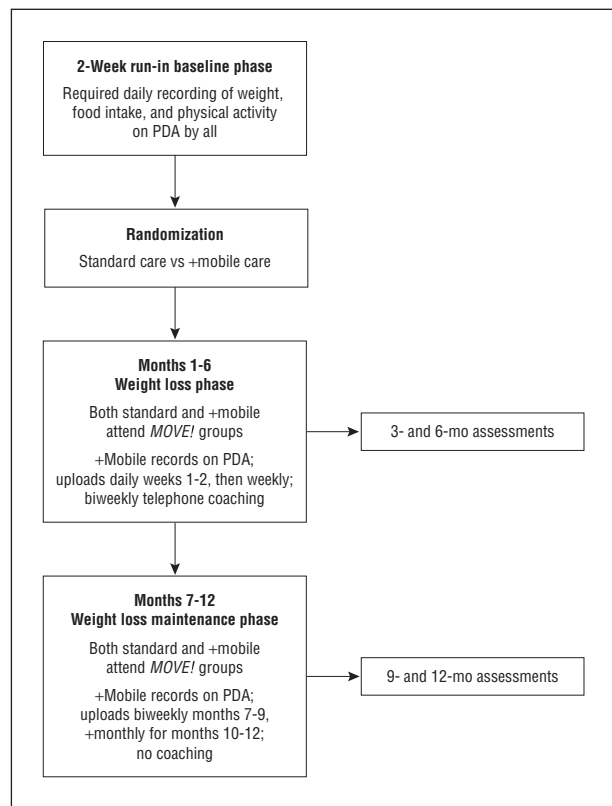
A challenge to obesity management is the need to implement access to intensive treatment within existing systems of care. Many physicians describe lack of time and training as barriers to providing behavioral treatment.<sup>6</sup> The Institute of Medicine suggests that interprofessional health

care teams have the diverse expertise needed for integrated care.<sup>7</sup> However, recent evidence suggests that intensive lifestyle interventions may not need to be performed in person. Among patients referred from primary care practices, Appel and colleagues<sup>8</sup> demonstrated that telephone- and

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Internet-based treatment produced weight loss comparable to an in-person intervention. Hybrid interventions that use technology and remote intervention components to augment existing in-person treatment programs could prove readily scalable. We tested the additive benefit of augmenting a system-wide group obesity



**Figure 1.** Trial phases. PDA indicates personal digital assistant.

program with a connective technology system that provided mobile decision support (ie, calorie and activity feedback). The technology allowed participants to transmit data to a behavioral coach who monitored their uploads and provided scheduled telephone coaching.

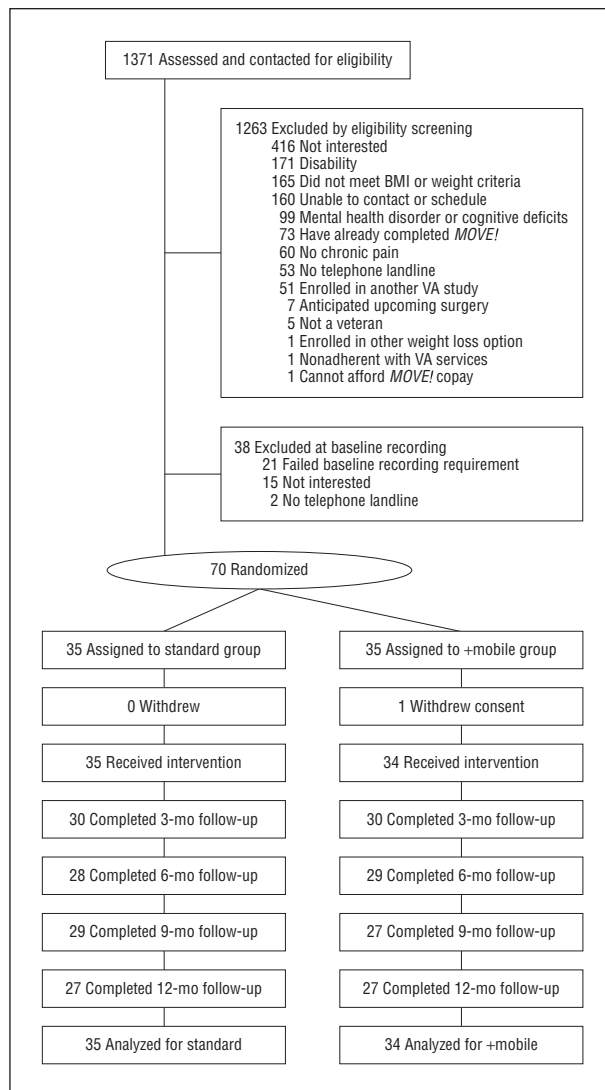
Self-monitoring of diet and physical activity is associated with weight loss success<sup>9</sup> and can be performed conveniently using handheld devices.<sup>10-12</sup> Mobile devices afford in-the-moment decision support by enabling users to check the energy value of foods and activities and track energy balance in real time.<sup>13,14</sup> Studies<sup>15,16</sup> of technology-supported weight loss interventions indicate that digital tools are more effective and acceptable to participants when they supplement rather than replace contact with human interventionists. Therefore, the current trial tested whether a connective mobile technology system, telephone coaching, and the standard-of-care obesity treatment improved weight loss outcomes compared with standard-of-care group obesity treatment alone. The standard of care was the MOVE! group weight loss program, offered at all Veterans Affairs (VA) medical centers.<sup>17</sup>

## METHODS

The study design and methods are presented in detail elsewhere<sup>18</sup> and are described briefly.

### SETTING AND PARTICIPANTS

From October 1, 2007, through September 31, 2010, we recruited overweight and obese adults at a Midwestern VA hos-



**Figure 2.** Participant flow. BMI indicates body mass index and VA, Veterans Affairs. Chronic pain was eliminated as a study entry criterion 1 year after the study began.

pital from those recently referred to MOVE! Inclusion criteria included a body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) between 25 and 40, weight less than 181.4 kg, and being able to participate in moderate-intensity physical activity. Recent psychiatric hospitalization, current substance abuse, binge eating disorder, or a severe mood disorder were exclusion criteria. **Figure 1** depicts the phases of the trial, and **Figure 2** shows participant flow throughout the trial. All study procedures were approved by the institutional review board at the VA hospital.

### RANDOMIZATION

Participants completed a technology fluency assessment<sup>19</sup> and received a brief (15-minute) training session on how to use a personal digital assistant (PDA) to record food intake, weight, and physical activity. They were loaned a PDA for 2 weeks and asked to upload their data daily. Those who entered their weight and recorded 2 or more meals (with  $\geq 2$  items per meal) per day for at least 7 days underwent an equipoise induction, which detailed the procedures and highlighted the pros and cons of both groups to equalize their desirability and

prevent dropout after randomization.<sup>20</sup> Participants were then randomly assigned either to standard-of-care group treatment alone (standard group) or to the standard plus connective mobile technology system (+mobile group). Randomization, stratified by age ( $\leq 65$  vs  $>65$  years), BMI ( $<35$  vs  $\geq 35$ ), and sex, was computer generated using the method of randomly permuted blocks.

## INTERVENTION (WEIGHT LOSS) PHASE

Participants assigned to the standard group returned the PDA when the 6-month intervention phase began; those assigned to the +mobile group retained the PDA. During months 1 through 6, both groups attended biweekly *MOVE!* sessions led by dietitians, psychologists, or physicians. Each session lasted approximately 1½ hours and included discussion of nutrition, physical activity, and behavior change.<sup>21</sup> Participants were given a 5% to 10% weight loss goal. They were weighed at each session and encouraged to self-monitor, but personalized feedback was not provided.

For participants assigned to the +mobile group, a goal feedback thermometer on the PDA was activated at the start of the intervention phase. By recording their foods throughout the day, the thermometer was automatically updated with current caloric intake, and participants used the PDA as a decision support tool to self-regulate energy intake. Participants uploaded their data every day for the first 2 weeks of the intervention and once per week thereafter until the end of month 6. After the first month of treatment, the coach introduced physical activity goals and activated a second goal feedback thermometer to depict progress toward a daily physical activity goal. During the 6-month intervention phase, a paraprofessional coach telephoned participants every 2 weeks to provide 10 to 15 minutes of individualized guidance based on the uploaded data and monitored the uploads to respond to technical difficulties.

Calorie goals were tailored according to the participant's baseline weight; activity goals were calculated using current activity level. Progress through the treatment algorithm was mastery based (triggered by accomplishment of each prior goal). If, after meeting calorie goals, participants did not lose weight for 2 consecutive weeks, they were instructed to reduce calories in 100-kcal increments until they reached a calorie intake level that yielded a weight loss rate of 0.5% to 1% of their current weight per week. For safety, no participant was given an intake goal below 1200 kcal/d. Conversely, if the rate of weight loss was too rapid (operationalized as weight loss of 1.4 kg per week for 4 consecutive weeks), the calorie intake goal was increased in 100-kcal increments until the goal of 0.5 to 0.9 kg of weight loss per week was attained. Daily physical activity goals (in minutes) were assigned by increasing self-reported baseline activity level by 25% after 1 month in the protocol. Subsequent physical activity goals were increased by 25% when participants met their previous goal. Goal activity counts were progressively increased until the criterion of an equivalent of 60 min/d of moderate-intensity physical activity was reached.

## WEIGHT LOSS MAINTENANCE PHASE

During the maintenance phase (months 7-12), participants in both groups attended monthly *MOVE!* support group sessions led by hospital staff. During months 7 to 9, +mobile group participants were asked to record and transmit data biweekly; during months 10 to 12, they transmitted 1 week of data per month. Throughout maintenance, coaches telephoned participants only if data were not submitted; they provided no other behavioral feedback.

## OUTCOMES

Weight was measured with the participant dressed in light clothing with shoes off on a calibrated balance beam scale at randomization and at 3-, 6-, 9-, and 12-month follow-up. The primary outcome was weight loss at 6 months; the secondary outcome was weight loss at 12 months. Weight loss was measured as change of weight in kilograms and as percentage of weight lost. Change in waist circumference and the proportion achieving a clinically significant 5% loss of initial body weight were exploratory outcomes. Assuming an SD of 5.4 kg, a sample size of 150 (75 per group) was projected to yield power of 0.80 to detect a 2.7-kg difference in weight loss between groups.

## STATISTICAL ANALYSIS

Weight change over time was analyzed with a longitudinal covariance pattern model, using an unstructured variance-covariance matrix.<sup>22</sup> Specifically, weight was modeled at all time points (at baseline and at 3, 6, 9, and 12 months) using a priori contrasts and treating baseline as the reference cell to assess weight change, relative to baseline, at the 4 postbaseline time points. Group effects on these a priori time contrasts were included to test for weight change differences between groups, and we specifically tested whether the group effect on weight change was equal or varied across the postbaseline time points. All stratification variables (age, BMI, and sex) were included in the analyses. Weight change was also expressed as a 5% or more weight loss relative to baseline at 3, 6, 9, and 12 months. These repeated binary outcomes were modeled using a generalized estimating equations logistic regression model for longitudinal data<sup>23</sup> with an unstructured working correlation matrix, and again we tested whether the group effect was equal or varied across the postbaseline time points.

## RESULTS

### STUDY PARTICIPANTS

The study sample of 69 adults included 59 men (85.5%), 21 minorities (30.4%), and 43 individuals (62.3%) with less than a college degree (mean [SD] age, 57.7 [11.9] years; range, 28-86 years; median, 60 years). Demographic information is summarized in the **Table**. Only 9 individuals (25.0%) of the subsample assessed ( $n=36$ ) reported full fluency<sup>19</sup> with rudimentary computer skills (eg, "I can print a document"). At baseline (randomization), the men had a mean (SD) weight of 114.3 (14.5) kg with a mean (SD) BMI of 36.3 (4.7). Women had a mean (SD) baseline weight of 96.3 (12.7) kg and a mean (SD) BMI of 36.4 (5.3). No differences in weight existed between treatment groups at baseline ( $P=.35$ ). The proportion of missing data ranged from 13.0% to 21.7% across postrandomization assessment periods, and the proportion of participants who attended all 4 outcome assessments was 73.9%.

### MOBILE TREATMENT

Participants assigned to the +mobile group lost a mean of 3.9 kg more (3.1% more weight loss relative to the control group) than participants in the standard group at each postbaseline time point (95% CI, 2.2-5.5 kg), and there was no evidence that the treatment effect varied across time ( $P=.44$ ). In terms of the specific time points, weight

**Table. Demographic Characteristics of the Study Participants at Randomization<sup>a</sup>**

Characteristic	Connective Mobile Group (n = 34)	Standard Group (n = 35)	Total (N = 69)
Age, mean (SD), y	57.7 (13.5)	57.7 (10.2)	57.7 (11.9)
Male sex	29 (42.0)	30 (43.4)	59 (85.5)
Ethnicity			
Hispanic or Latino	1 (2.9)	3 (8.6)	4 (5.8)
Not Hispanic or Latino	33 (97.1)	32 (91.4)	65 (94.2)
Race			
White	25 (73.5)	27 (77.1)	52 (75.4)
Black or African American	9 (26.5)	8 (22.9)	17 (24.6)
College graduate	10 (29.4)	14 (40.0)	26 (37.7)
Anthropometry, mean (SD)			
Weight, kg	113.7 (16.1)	110.1 (15.1)	111.1 (15.6)
BMI	36.9 (5.4)	35.8 (3.8)	36.3 (4.6)
Waist circumference, cm	120.4 (14.0)	120.4 (8.9)	120.4 (11.7)

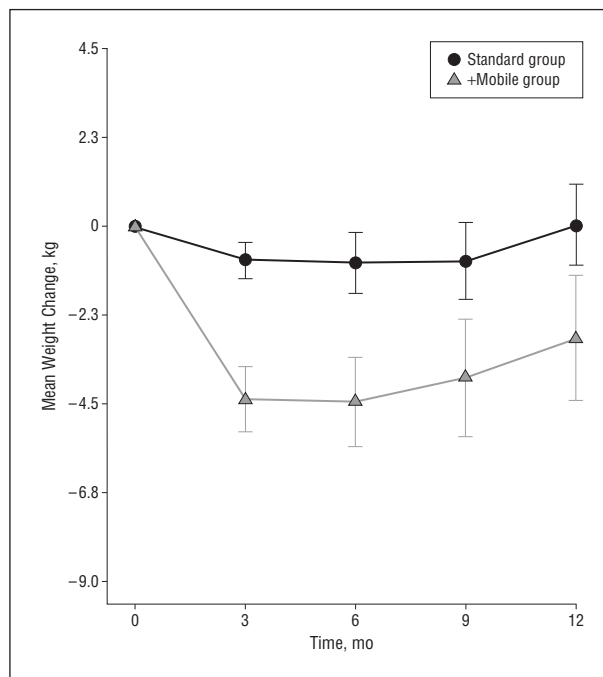
Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

<sup>a</sup>Data are presented as number (percentage) of study participants unless otherwise indicated. No between-group differences in baseline variables were observed.

loss was greater for the +mobile group (4.4 kg; 95% CI, 2.7-6.1 kg) than the standard group (0.86 kg; 95% CI, 0.04-1.8 kg) at 3 and 6 months (+mobile group: 4.5 kg; 95% CI, 2.1-6.8 kg; standard group: 1.0 kg; 95% CI, -0.7 to 2.5 kg), 9 months (+mobile group: 3.9 kg; 95% CI, 0.8 to 6.9 kg; standard group: 0.9 kg; 95% CI, -1.1 to 2.9 kg), and 12 months (+mobile group: 2.9 kg; 95% CI, 0.5 to 6.2 kg; standard group: -0.02 kg; 95% CI, -2.1 to 2.1 kg). These data are shown in **Figure 3**. In terms of 5% or more weight loss, a significant group effect favoring the +mobile intervention was observed (odds ratio, 6.5; 95% CI, 2.5-18.6), and this effect did not vary significantly across time ( $P = .13$ ). The observed proportions of participants achieving the 5% criterion were as follows: at 3 months, 36.7% in the +mobile group vs 0% in the standard group; at 6 months, 41.4% in the +mobile group vs 10.7% in the standard group; at 9 months, 33.3% in the +mobile group vs 10.3% in the standard group; and at 12 months, 29.6% in the +mobile group vs 14.8% in the standard group.

#### MOBILE TREATMENT AND MOVE! ADHERENCE

No difference was found in how frequently participants assigned to the +mobile group attended MOVE! groups compared with those assigned to the standard MOVE! group treatment alone (mean number attended, 6.2 meetings in the +mobile group vs 5.9 meetings in the standard group) ( $P = .54$ ). However, participants randomized to the +mobile group who were also adherent to MOVE! treatment, as evidenced by attending 80% or more of treatment sessions, lost significantly more weight than less adherent +mobile group participants and adherent or nonadherent standard group participants (**Figure 4**).



**Figure 3.** Weight loss plotted over time for the connective mobile technology (+mobile) and standard groups. Weight loss was significantly greater for the +mobile group at 3, 6, and 9 months.

#### MOBILE TREATMENT CALLS COMPLETED

Of the recommended 12 coaching calls, the average +mobile participant received 74.4% (mean [SD], 8.9 [2.8] calls; range, 0-15 calls; median, 8 calls), lasting a mean (SD) 125.6 (48.8) minutes (median, 125 minutes) per participant. Total additional time spent on technical support calls averaged a mean (SD) of 15.3 (5.4) minutes (median, 10 minutes) per participant.

#### COMMENT

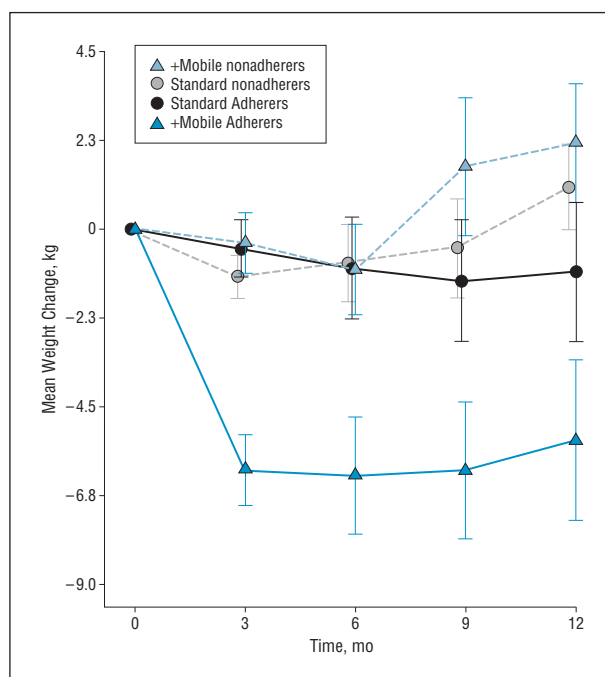
The current study demonstrates the feasibility of using mobile connective technology to interface with a hospital-based, standard-of-care weight loss treatment. Adding technology and coaching to the standard-of-care group obesity treatment significantly enhanced weight loss outcomes at 3, 6, 9, and 12 months. More than 36% of participants using the mobile technology system and coaching, compared with 0% in the standard-of-care condition, lost at least 5% of their initial body weight at 3 months, a degree of weight loss that has been shown to improve cardiovascular disease risk biomarkers.<sup>24,25</sup> These findings indicate that it is possible to implement an intensive behavioral weight loss intervention that is easy to access, effective, and readily integrated into an existing system of care.

The current results are, to our knowledge, the first to demonstrate that use of a mobile technology system and remote coaching can significantly augment weight loss and maintenance when added to an existing standard-of-care obesity treatment program. Previous PDA-based weight loss interventions have been successful in producing weight losses at 6 months of 5.5% to 7.3%. How-

ever, in those studies, the PDA was used in conjunction with an intensive, in-person, researcher-directed behavioral weight loss program that required participants to attend 20 to 24 in-person treatment sessions.<sup>12,26</sup> The current study demonstrates that significant, sustained weight loss can be produced when the PDA and up to 12 brief biweekly telephone calls are combined with 12 group sessions during a 6-month period. Instead of requiring participants to attend 8 to 12 additional treatment sessions, each lasting 90 minutes plus commuting time, those in the current study received a mean of 8 coaching calls, each lasting approximately 14 minutes. This substantial reduction in cost and travel burden placed on participants would be expected to increase the program's appeal to the public and its feasibility of implementation. Moreover, unlike prior obesity interventions using mobile technology, the +mobile group maintained significant weight loss during the maintenance phase (months 7-12), even though meeting frequency was reduced to monthly sessions and coaching calls were discontinued. These results suggest that the addition of a mobile technology system and coaching calls to clinician-directed standard-of-care obesity treatment can enhance weight loss outcomes at low added burden and cost.

The current mobile connective technology system was unique in that the coach tracked and supportively held participants accountable for self-monitoring.<sup>15,27</sup> Coaches provided timely, tailored feedback on calls because data had been transmitted and analyzed beforehand. Failure to upload data for several days led the coach to suspect technical difficulties and reach out to the participants. In contrast, prior weight loss interventions mediated by mobile devices sent automated rather than personally crafted text messages and delayed feedback on participants' hand-delivered data for at least a week because coaches needed time to study it.<sup>12,26,28,29</sup> When used to record diet and activity without behavioral support, digital self-monitoring lacks a weight loss advantage over paper-and-pencil recording.<sup>29</sup>

Consistent with results of the current study, recent systematic reviews of technology-based weight loss interventions conclude that technology is a promising way to produce clinically significant weight loss in overweight and obese adults.<sup>16,30</sup> In addition to PDAs, a range of devices have been tested as primary channels or adjuncts for delivering treatment, including computers,<sup>28,31</sup> Internet,<sup>32-37</sup> text messages,<sup>38,39</sup> and physical activity monitors.<sup>40,41</sup> Weight loss varied depending on the specific technology, amount and type of interventionist contact, and duration of the intervention. In general, greater weight loss (5.7-8.8 kg) occurs when technology is combined with weekly in-person contact.<sup>12,40-42</sup> However, because in-person interventionist contact is the most expensive treatment component to provide and the most burdensome to access, we substituted brief, regularly scheduled telephone coaching to which coaches came prepared by having reviewed participants' transmitted, analyzed data. Results suggest that connective technology, like that used in the current study, can allow telephone contact to substitute efficiently for face-to-face time.



**Figure 4.** Weight loss over time as a function of treatment assignment and *MOVE!* adherence. Participants in the connective mobile technology (+mobile) group who were adherent to *MOVE!* treatment (ie, attended  $\geq 80\%$  of treatment sessions) lost significantly more weight than less adherent +mobile participants and either adherent or nonadherent standard-of-care participants. Data were available from the following: standard adherers, 15 participants at baseline and 13 at month 12; standard nonadherers, 20 at baseline and 14 at month 12; +mobile adherers, 21 at baseline and 18 at month 12; and +mobile nonadherers, 13 at baseline and 9 at month 12.

Other intervention components could conceivably be automated for added efficiency.

Strengths of this study include the demonstration that a technology-based intervention can be integrated into the VA, a large system of care, suggesting that the treatment approach is scalable. The demographics of the sample, which consisted primarily of men (85.5%), are also a strength, given that most weight loss studies include predominantly women.<sup>9,43</sup> More important, the sample also represented a population subgroup that has been slow to adopt technology: older adults with less than a college education.<sup>44</sup> Our participants used the PDA effectively after a brief training session, which accords with other evidence that older adults increasingly use technology.<sup>45,46</sup> For example, 81% of 55- to 64-year-olds and 56% of those who are 65 years or older own a cell phone.<sup>47</sup> Mobile devices and apps have become accessible to a degree that was unimaginable previously.<sup>47</sup> Therefore, interventions, such as the present one, that use technology to augment an existing care system hold great potential to advance population health.

Despite the study's strengths, some limitations warrant consideration. The fact that the study was conducted at a VA medical center outpatient clinic limits generalizability. The VA system is atypical in having well-established, integrated preventive care programs by virtue of its commitment to population-level health care. Nevertheless, our intervention significantly augmented the weight loss outcomes produced by the VA's standard-of-care weight loss program.

Our intervention incorporated 2 main components: a mobile device that provided feedback about diet and activity and regular telephone coaching that was informed by a knowledge of participants' self-monitoring behavior. As for most treatment packages, the impact of these 2 components cannot be disentangled at present. For comparison, Appel and colleagues<sup>8</sup> found that adding 21 coaching calls to didactic lessons on the Internet produced weight loss comparable to 18 in-person treatment sessions. We augmented an institution's preexisting, biweekly, in-person obesity treatment program with fewer telephone coaching calls (12 calls), presumably rendered better tailored and more efficient because coaches were preinformed via participants' mobile uploads. Our trial illustrates an optimization strategy whereby medical practices can test whether adding or reconfiguring current treatment strategies in their setting would improve local outcomes cost-effectively.<sup>48</sup> Although the current study used older-generation technology, newer technologies, including smartphones, retain enhanced functionalities of a PDA and are on track to be used by most of the population in the next 3 years.<sup>47</sup> These technological advancements, used in conjunction with standard-of-care obesity treatment, may greatly enhance scalability.

In sum, this study highlights the promise of a mobile technology system as a scalable, cost-effective means to augment the effectiveness of physician-directed weight loss treatment. Technology offers new channels to reconfigure the provision of effective components of behavioral weight loss treatment (ie, self-monitoring, goal setting, lifestyle counseling, and in-person sessions).<sup>8,16,49,50</sup> A handheld tool that provides decision support for self-monitoring embraces patient-centered care by helping patients manage their own behavior change. By enabling trained paraprofessionals to provide highly personalized treatment remotely, at reduced cost and participant burden, connective technology systems can help to ease the burden on strained care systems.

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Author Contributions: Dr Spring had full access to all the study data and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Spring, Janke, Kozak, Hedeker, and Epstein. *Acquisition of data:* Duncan, Demott, and Pictor. *Analysis and interpretation of data:* Hedeker, Spring, Siddique, McFadden, and Duncan. *Drafting of the manuscript:* Spring, Duncan, Janke, Kozak, and Hedeker. *Critical revision of the manuscript for intellectual content:* Janke, Kozak, Hedeker, Pellegrini, and Buscemi. *Obtained funding:* Spring. *Administrative, technical, or material support:* Duncan, McFadden, Demott, and Pictor. *Study supervision:* Spring, Janke, and Kozak.

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**INVITED COMMENTARY**

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## The Future of Obesity Treatment

### *Accessible, Inexpensive, and Technology Based?*

A staggering 68% of US adults are either overweight or obese.<sup>1</sup> Current direct medical costs associated with treating obesity-related illness are roughly 5% to 10% of all US health care spending.<sup>2</sup> Effective solutions to this epidemic are scarce, expensive, or both. The mean cost of bariatric surgery is \$27 905.<sup>3</sup> Few medications are available for weight loss, and despite recent promising developments, obesity drugs are unlikely to become a solution to the problem.<sup>4</sup> Many believe significant changes in public policy and the built environment will be necessary to reverse the epidemic.<sup>5,6</sup> Such changes require a great deal of political will, which is lacking, and in any case would take many years to have a significant effect. So, what on earth should we do right now or in the near future?

A limited number of modestly effective behavioral weight management programs are available but expensive. Our medical community desperately needs new approaches that meet 3 criteria. First, weight management programs should be convenient and accessible to most people in need. Second, these programs must

cost significantly less than current alternatives. Technology can play a crucial role in providing low-cost, accessible weight management. Finally, participation should be sustainable, even if programs have only a modest effect on weight. Weight management is often a lifelong struggle, so it is essential that these programs have the ability to retain or reengage people for many years. This is why strategies that take advantage of the long-term relationship of patients with primary care physicians are so important.<sup>7</sup>

Unfortunately, most weight management research has been performed in specialized rather than primary care settings. The few studies performed in primary care have significant shortcomings. We conducted a simple, rather than comprehensive, PubMed search of clinical trials using the keywords *obesity* and *weight loss*, which yielded roughly 3200 articles. When that search was narrowed by adding the keyword *primary care*, only 143 articles remained. We were able to classify most interventions described in these 143 articles into 2 types: simple and