Comparison of Strategies for Sustaining Weight Loss
The Weight Loss Maintenance Randomized Controlled Trial

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Context Behavioral weight loss interventions achieve short-term success, but regain is common.

Objective To compare 2 weight loss maintenance interventions with a self-directed control group.

Design, Setting, and Participants Two-phase trial in which 1032 overweight or obese adults (38% African American, 63% women) with hypertension, dyslipidemia, or both who had lost at least 4 kg during a 6-month weight loss program (phase 1) were randomized to a weight-loss maintenance intervention (phase 2). Enrollment at 4 academic centers occurred August 2003-July 2004 and randomization, February-December 2004. Data collection was completed in June 2007.

Interventions After the phase 1 weight-loss program, participants were randomized to one of the following groups for 30 months: monthly personal contact, unlimited access to an interactive technology-based intervention, or self-directed control.

Main Outcome Changes in weight from randomization.

Results Mean entry weight was 96.7 kg. During the initial 6-month program, mean weight loss was 8.5 kg. After randomization, weight regain occurred. Participants in the personal-contact group regained less weight (4.0 kg) than those in the self-directed group (5.5 kg; mean difference at 30 months, −1.5 kg; 95% confidence interval [CI], −2.4 to −0.6 kg; P = .001). At 30 months, weight regain did not differ between the interactive technology-based (5.2 kg) and self-directed groups (5.5 kg; mean difference −0.3 kg; 95% CI, −1.2 to 0.6 kg; P = .51); however, weight regain was lower in the interactive technology-based than in the self-directed group at 18 months (mean difference, −1.1 kg; 95% CI, −1.9 to −0.4 kg; P = .003) and at 24 months (mean difference, −0.9 kg; 95% CI, −1.7 to −0.02 kg; P = .04). At 30 months, the difference between the personal-contact and interactive technology-based group was −1.2 kg (95% CI −2.1 to −0.3; P = .008). Effects did not differ significantly by sex, race, age, and body mass index subgroups. Overall, 71% of study participants remained below entry weight.

Conclusions The majority of individuals who successfully completed an initial behavioral weight loss program maintained a weight below their initial level. Monthly brief personal contact provided modest benefit in sustaining weight loss, whereas an interactive technology-based intervention provided early but transient benefit.

Trial Registration clinicaltrials.gov Identifier: NCT00054925

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weight and obesity epidemic, there is a critical need for practical, affordable, and scalable intervention strategies that effectively maintain weight loss. Such strategies may also play an important role in preventing weight gain among normal-weight individuals, thereby reducing the incidence of overweight and obesity.12

Despite the potential for health benefits of weight loss maintenance, there is little evidence, particularly from clinical trials, on how to accomplish this objective. Observational studies suggest that continued intervention contacts9-11, self-monitoring of dietary intake, physical activity, and weight14-16; accountability10,14, and regular physical activity17 lead to sustained weight loss. However, very few trials have explicitly tested alternative strategies to sustain weight loss, and few weight loss studies have implemented interventions for longer than 18 months.13,14,18-20

METHODS
Participants were enrolled in 2 phases of the clinical trial: phase 1 was a 6-month nonrandomized initial weight loss intervention for all participants; phase 2 was a randomized 30-month trial comparing 2 weight-maintenance strategies (personal contact and interactive technology) vs a self-directed control condition.

Participants to be included into phase 1 of the study, participants were required to have a body mass index (BMI), calculated as weight in kilograms divided by height in meters squared, of between 25 and 45; to be taking medication for hypertension, dyslipidemia, or both; to have no active CVD (those with a positive Rose angina questionnaire or a CVD event no less than 12 months before study entry and a negative stress test result could join the study with permission from their physician); access to a telephone and to the Internet; and to keep a food diary for 5 days during the screening.

Major exclusion criteria for phase 1 were medication-treated diabetes mellitus, a recent cardiovascular event or other medical or psychiatric conditions that would preclude full participation in the study, weight loss of more than 9 kg in the last 3 months, recent use of weight loss medications, or prior weight loss surgery. The primary criterion for randomization into the study’s second phase was weight loss of at least 4 kg during the first phase.

Recognizing that weight loss studies often lack large numbers of male participants, we sought to enroll 40% men. In addition, a major trial goal was to recruit a study population that was approximately 40% African American. Participants self-identified their race categories.

Participant Flow
Recruitment relied on mass mailings, posted flyers, radio advertisements, and print media. Individuals meeting prescreening criteria attended a series of prescreening visits, after which eligible participants began the 6-month group-based, phase 1 behavioral weight-loss program, for which enrollment occurred from August 2003 through July 2004. Those who completed phase 1 and met criteria for phase 2 were randomized from February through December 2004 to one of the 3 interventions. Data collection was completed in June 2007.

Randomization assignments were stratified by clinic, race (ie, African American or non–African American), and amount of weight loss during phase 1 and were allocated in blocks of varying sizes to provide balance in treatment assignments over time. The actual allocation assignments were generated using a password-protected, Web-based application developed by the coordinating center and were accessible only to authorized unblinded personnel.

Measurements
Data collection visits occurred at study entry and at the end of phase 1 (ie, at randomization, also referred to as baseline) and every 6 months after randomization for 30 months (2½ years). Measurements were obtained by trained, certified staff members who were masked to treatment assignment.

Weight was measured in duplicate with the participant wearing light indoor clothes without shoes and using a high-quality, calibrated digital scale. At baseline and at 12 and 30 months after randomization, weight was measured on
2 separate days, and values were averaged. At other times, weight was measured at a single clinic visit. Height was measured once at entry using a calibrated, wall-mounted stadiometer.

Dietary intake and physical activity were measured at entry, randomization, and the 12- and 30-month follow-up visits. Diet was assessed by the Block food frequency questionnaire. Physical activity was measured by accelerometry. Participants were asked to wear a calibrated, triaxial accelerometer (RT3, Stayhealthy Inc, Monrovia, California) for at least 10 hours per day for at least 4 days, including 1 weekend day. Accelerometry results that comprised at least 1 weekday and 1 weekend day were used to estimate total weekly minutes of moderate to vigorous physical activity (MVPA). Total MVPA reflects both leisure time exercise and daily activity patterns (such as climbing stairs) and thus provides a measure of total MVPA-related energy expenditure.

**Initial Weight Loss Intervention**

The phase 1 intervention was a group-based behavioral intervention. A trained interventionist led 20 weekly group sessions over approximately 6 months. Intervention goals were for participants to reach 180 minutes per week of moderate physical activity (typically walking), reduce caloric intake; adopt the Dietary Approaches to Stop Hypertension dietary pattern, which has been shown to reduce CVD risk factors, and lose approximately 1 to 2 lb per week. Part-

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**Figure 1. Flow Chart of Enrollment, Randomization, and Follow-up**

- 3178 Individuals eligible after prescreening
  - 776 Dropped out
  - 2402 Started in-person screening
    - 717 Excluded
      - 44 Eligible but withdrew
      - 21 Medication exclusion
      - 9 Body mass index < 25
      - 91 Body mass index > 45
      - 66 Lack of motivation
      - 22 No internet access
      - 68 Other
      - 396 Incomplete screen, reason unknown
  - 1685 Entered weight loss intervention (phase 1)
    - 653 Excluded
      - 131 No final weight
      - 418 Lost < 4 kg
      - 2 Refused participation
      - 1 Died
      - 25 Member of a household with a randomized participant
      - 76 Declined or otherwise ineligible

<table>
<thead>
<tr>
<th>PHASE 1</th>
<th>PHASE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1032 Randomized into phase 2</td>
<td></td>
</tr>
<tr>
<td>342 Randomized to self-directed weight loss maintenance</td>
<td></td>
</tr>
<tr>
<td>348 Randomized to receive interactive technology intervention</td>
<td></td>
</tr>
<tr>
<td>342 Randomized to receive personal-contact intervention</td>
<td></td>
</tr>
<tr>
<td>341 Included in primary analysis</td>
<td></td>
</tr>
<tr>
<td>347 Included in primary analysis</td>
<td></td>
</tr>
<tr>
<td>341 Included in primary analysis</td>
<td></td>
</tr>
</tbody>
</table>

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*Medications included antipsychotic agents and those that treat diabetes and overweight and obesity.

Outcome data imputed for participants with missed visit; therefore, excluding 3 deaths, all 1029 randomized participants are included in this analysis.

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participants were taught to keep food and physical activity self-monitoring records and to calculate caloric intake.

**Maintenance Interventions**

Participants included in the study’s second phase were randomly assigned to 1 of 3 groups: a self-directed comparison condition in which participants received minimal intervention, an interactive technology–based intervention in which participants were encouraged to regularly log on to an interactive Web site; and a personal-contact intervention in which participants had monthly individual contact with an interventionist. The goals of the interactive technology–based and personal-contact interventions were maintenance of the phase 1 weight loss or loss of additional weight if desired, continued adherence to the recommended dietary pattern, and increasing moderate physical activity to at least 225 minutes per week.31,34

Both personal-contact and interactive technology–based interventions reinforced the key theoretical constructs (motivation, support, problem solving, and relapse prevention) that had been incorporated in phase 1. In addition, both active interventions incorporated features found to be associated with maintenance of behavior change in previous studies, such as continual intervention contacts, self-monitoring, accountability, prolonged continuous contact, and motivational interviewing. The counseling strategies and dietary and physical activity recommendations were the same in the personal-contact and interactive technology–based groups. Both maintenance interventions were designed to be easily disseminated and practical to implement.

At randomization, participants in the self-directed group received printed lifestyle guidelines with diet and physical activity recommendations, and they met briefly with a study interventionist again after the 12-month data collection visit.

The interactive technology–based intervention included unlimited access to a Web site designed to support weight loss maintenance.33 Interactive features allowed participants to set personal goals and action plans for the next week and to graph personal data over time. Modules addressed problem solving and motivation, and a bulletin board facilitated social support but did not provide in-person counseling.

When participants logged on, they were required to enter their current weight and were encouraged to use the Web site for self-monitoring of physical activity and caloric intake. Participants were encouraged to log on at least once a week. If they missed a self-scheduled contact, they were sent an e-mail reminder that was repeated after another week of no contact. If there was no response to 2 e-mail prompts, participants received 2 weekly automated telephone calls. If there was no subsequent log-on, study staff contacted the participant and encouraged him/her to return to the Web site.

The personal-contact intervention consisted of a case management approach with monthly person-to-person guidance and support. Participants had telephone contact with an interventionist for 5 to 15 minutes each month, ex-

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**Table 1. Characteristics of Participants Randomized to Phase 2**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Self-directed (n = 342)</th>
<th>Internet Technology (n = 348)</th>
<th>Personal Contact (n = 342)</th>
<th>Total Randomized Population (n = 1032)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>28 to 83</td>
<td>55.8 (8.5)</td>
<td>55.7 (8.5)</td>
<td>55.4 (9.1)</td>
</tr>
<tr>
<td>Race/ethnicity and sex distribution, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>90 (26)</td>
<td>90 (26)</td>
<td>87 (25)</td>
<td>267 (26)</td>
</tr>
<tr>
<td>Men</td>
<td>35 (11)</td>
<td>41 (12)</td>
<td>45 (13)</td>
<td>121 (12)</td>
</tr>
<tr>
<td>Non–African American</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>131 (38)</td>
<td>130 (37)</td>
<td>126 (37)</td>
<td>387 (37)</td>
</tr>
<tr>
<td>Men</td>
<td>86 (25)</td>
<td>87 (25)</td>
<td>84 (25)</td>
<td>257 (25)</td>
</tr>
<tr>
<td>Weight, mean (SD), kg</td>
<td>59.2 to 158.0</td>
<td>95.9 (16.2)</td>
<td>97.1 (16.9)</td>
<td>96.7 (16.6)</td>
</tr>
<tr>
<td>BMI, mean (SD)</td>
<td>25.1 to 46.7</td>
<td>34.0 (4.8)</td>
<td>34.2 (4.9)</td>
<td>34.1 (4.8)</td>
</tr>
<tr>
<td>BMI weight category, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight, 25 to 29.9</td>
<td>139 (41)</td>
<td>131 (38)</td>
<td>129 (38)</td>
<td>399 (39)</td>
</tr>
<tr>
<td>Stage 1</td>
<td>139 (41)</td>
<td>131 (38)</td>
<td>129 (38)</td>
<td>399 (39)</td>
</tr>
<tr>
<td>Stage 2</td>
<td>30 to 34.9</td>
<td>139 (41)</td>
<td>131 (38)</td>
<td>129 (38)</td>
</tr>
<tr>
<td>≥35</td>
<td>127 (37)</td>
<td>141 (40)</td>
<td>135 (39)</td>
<td>403 (39)</td>
</tr>
<tr>
<td>Medications, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>294 (86)</td>
<td>301 (86)</td>
<td>302 (88)</td>
<td>897 (87)</td>
</tr>
<tr>
<td>Lipid</td>
<td>136 (40)</td>
<td>137 (39)</td>
<td>138 (40)</td>
<td>411 (40)</td>
</tr>
<tr>
<td>Education, No (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some college or less</td>
<td>135 (39.5)</td>
<td>132 (37.9)</td>
<td>130 (37.9)</td>
<td>396 (38.4)</td>
</tr>
<tr>
<td>College degree</td>
<td>207 (60.5)</td>
<td>206 (62.1)</td>
<td>212 (62.1)</td>
<td>636 (61.6)</td>
</tr>
<tr>
<td>Household income/y, $</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;60,000</td>
<td>147 (43.0)</td>
<td>137 (39.3)</td>
<td>155 (45.5)</td>
<td>440 (42.6)</td>
</tr>
<tr>
<td>≥60,000</td>
<td>195 (57.0)</td>
<td>211 (60.7)</td>
<td>186 (54.5)</td>
<td>592 (57.4)</td>
</tr>
<tr>
<td>Phase 1 weight change, mean (SD), kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>–4.0 to –30.3</td>
<td>–8.5 (4.0)</td>
<td>–8.6 (4.5)</td>
<td>–8.3 (4.2)</td>
<td>–8.5 (4.2)</td>
</tr>
<tr>
<td>53.7 to 148.3</td>
<td>87.4 (15.3)</td>
<td>88.6 (15.4)</td>
<td>88.7 (16.9)</td>
<td>88.2 (15.8)</td>
</tr>
<tr>
<td>Energy intake at randomization, mean (SD), kcal/d</td>
<td>1596.8</td>
<td>(532.9)</td>
<td>1588.6</td>
<td>(520.7)</td>
</tr>
<tr>
<td>Physical activity at randomization, mean (SD), min MVPA/wk</td>
<td>158.8</td>
<td>(141.9)</td>
<td>159.1</td>
<td>(136.6)</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index, calculated as weight in kilograms divided by height in meters squared; MVPA, moderate to vigorous physical activity.

*All values are at start of phase 1 unless otherwise specified. Some actual numbers may not sum to 1032 due to missing data.*
serve the experiment-wide type I error
directed control condition. To correct for
treatment was compared with the self-
Amendment Act of 2001.37 The personal-
Medicare Medical Nutrition Therapy
consistent with recommendations of the
tervention was based on previous trials9,10,35 and on
disease management programs36 and is
with a self-reported weight (or mea-
contact intervention did not involve In-
Each personal-contact session began
and a review of progress since the last
contact, including number of days on
which a food diary was kept, fre-
quency of weighing, average number of
minutes of exercise, and progress on ad-
ontrol and interactive technology–
ated those for the primary outcome
analysis, except that they adjusted for
level and phase 1 change of the
outcome of interest (energy intake or
MVPA) rather than weight. To
power for secondary outcomes, the
protocol stipulated a priori that no
multiple comparisons correction would
be made for these analyses. We also
used similar models to test for interac-
tions with prespecified subgroups.
the case of race-sex subgroups, clini-
cal interest in these subgroups led to
an analysis of treatment effects separ-
ately in each stratum despite the ab-
sence of significant interaction.
We used multiple imputation41,42 to
replace missing end-of-study weights
(for 68 individuals), missing interim
weights, and other measures. Only
weights missing due to participant
death (n=3) were not imputed.
Consequently, all 1029 randomized pa-
ticipants who survived are included in
the primary outcome analysis. To de-
rive imputed end-of-study weights, we
used interim weights and variables re-
lated to phase 1 weight loss to esti-
mate the parameters of a multivariate
distribution from which imputed val-
ues were drawn, creating 5 separate im-
putation samples. Results presented
herein are the average of separate, iden-
tical analyses performed on each of
these 5 complete data sets, with appro-
priate adjustment of standard errors43
to incorporate the added variability over
imputations. Hence, the standard er-
ers are somewhat inflated relative to
what would be observed using only a
single-imputation sample.
The originally anticipated phase 2
sample size of 800 was designed to pro-
vide 90% power to detect a 2.0-kg dif-
fERENCE in weight change between either
of the active interventions (personal con-
tact or interactive technology) vs the self-
directed strategy and 80% power to de-
tect treatment differences of about 2.9 kg
in an expected subset of 320 African
Americans. All analyses were con-
ducted using SAS, version 9.1 (SAS In-
istute Inc, Cary, North Carolina), and
all P values are 2 sided.

RESULTS
A total of 1685 individuals partici-
pated in phase 1, the initial weight loss
intervention, of whom 1032 (61%) met
phase 2 entry criteria (FIGURE 1). TABLE 1 shows that 63% of those ran-
domized were women and 38%, Afri-
can American, with a mean age of 55.6
years (range, 28-83 years) and a mean
initial weight loss of 8.5 kg (range, 4.0-
30.3 kg).
Follow-up rates were 93% to 96% at
each major data collection visit
(Figure 1). There were no notable dif-
fferences in participant characteristics at
entry into the study between those who
completed the final data-collection visit
and the 68 individuals who did not (data
not shown). Three participants (1 in each
treatment group) died after randomiza-
tion and are not included in the inten-
tion-to-treat analysis, which is there-
fore based on 1029 participants.
Participants in the interactive tech-
nology group logged onto the Web site
an average of once a week and had at
least 1 Web site contact for 77% of the
months of the maintenance phase. Par-
ticipants in the personal-contact group
completed an average of 91% of
monthly intervention contacts.

Change in Energy Intake
and Expenditure
Self-reported energy intake decreased
by approximately 325 kcal/d during
phase 1 but increased slightly but not

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significantly during phase 2: 88 kcal/d in the self-directed group, 16 kcal/d in the interactive technology–based group, and 55 kcal/d in the personal-contact group. At the end of follow-up, caloric intake remained lower than entry levels by 231, 326, and 272 kcal/d, respectively. Changes in energy intake did not differ significantly between treatment groups: −33 kcal/d (95% confidence interval [CI], −117 to 51 kcal/d) for the personal-contact vs the self-directed, −72 kcal/d (95% CI, −168 to 24 kcal/d) for the interactive technology vs the self-directed, and 39 kcal/d (95% CI, −45 to 123 kcal/d) for the personal-contact vs the interactive technology groups.

During phase 1, participants increased their MVPA by about 48 minutes, but that decreased significantly in all 3 groups after randomization to the maintenance phase of the study by 32 minutes in the self-directed, 35 minutes in the interactive technology, and 33 in the personal-contact groups. By the end of follow-up, participants’ exercise levels were not significantly higher than the amount of time they exercised at study entry. Changes in MVPA in phase 2 did not differ significantly between groups: −5 min/wk (95% CI, −24 to 14 min/wk) for personal-contact vs self-directed, −8 min/wk (95% CI, −27 to 12 min/wk) for the interactive technology–based vs the self-directed group, and 4 min/wk (95% CI, −11 to 18 min/wk) for the personal-contact vs the interactive technology–based groups.

**Weight Outcomes**

All groups regained weight after randomization by a mean of 5.5 kg in the self-directed, 5.2 kg in the interactive technology–based, and 4.0 kg in the personal-contact group (FIGURE 2, TABLE 2). However, the mean weight at 30 months remained lower in each group than mean weight at entry into the study (Figure 2, Table 2). As shown in Table 3, at 30 months after randomization on average, those in the personal-contact group regained 1.5 kg less weight than those in the self-directed group (95% CI, 2.4–0.6 kg; P = .001), whereas those in the interactive technology–based group regained only 0.3 kg less than those in the self-directed group (95% CI, 1.2–0.6 kg; P = .51). Those in the personal-contact group regained a mean of 1.2 kg less than those in the interactive technology–based group (95% CI, 2.1–0.3 kg; P = .008). As expected, the pattern of results is similar when the outcome is expressed as percentage weight change (personal-contact vs self-directed group difference, −1.8%; P < .001; interactive technology–based vs self-directed group difference, −0.4%; P = .5; personal-contact vs interactive technology–based group difference, −1.5%; P = .003, data not shown).

Additional analyses reported in Table 3 demonstrate that participants in both the interactive technology–based and personal-contact groups experienced significantly less weight regain than those in the self-directed group at each follow-up visit for 24 months following randomization.

At the end of follow-up, there were no significant interactions with baseline BMI, age, or race. Nevertheless, given the strong clinical and public health interest in the impact of obesity in African Americans, we report weight changes in race-sex subgroups. Table 4 shows that the magnitude of the observed treatment effects was generally consistent across these groups; in the absence of significant interaction, any apparent differences must be interpreted cautiously.

Post hoc sensitivity analyses removing 2 outliers (a participant in the interactive technology–based group who lost 30 kg and a participant in the self-directed group who gained 60 kg in phase 2) did not substantively change the results. Even without these outliers (both of whom were verified) the range of weight change after randomization was large in each group (self-directed range, −12 to 26 kg; interactive technology–based range, −12 to 24 kg; and personal-contact range, −17 to 25 kg).

A sizeable proportion of participants in each treatment group sustained clinically significant weight loss (TABLE 5). Overall, 41.8% of participants maintained at least 4 kg of weight loss compared with entry weight, with no significant differences between treatment groups; 70.9% remained at or below their entry weight. The proportion maintaining this much weight loss was significantly higher in the personal-contact group than in the self-directed group (P = .003), as was the difference between the personal-contact and interactive technology–based groups (P = .03). Also, 37.1% overall remained 5% or more below entry weight. The difference between the self-directed and personal-contact groups was significant (P = .02). Finally, 31.5% regained no more than 3% higher than their randomization weight. These percentages do not differ between treatment groups.
COMMENT

In this study of overweight and obese adults, who are at high risk of CVD, those who were randomly assigned to the personal-contact intervention regained significantly less weight over a 30-month period than those assigned to the self-directed and interactive technology–based interventions. The personal-contact intervention was effective across all subgroups—men and women, African Americans and non-African Americans, and younger and older adults—suggesting the potential for broad public health impact. Because most personal-contact intervention contacts consisted of monthly 10- to 15-minute telephone conversations, this is an efficient and practical mode of delivery.

Although weight regain with the personal-contact intervention was statistically less than weight regain in the self-directed control group, the mean effect was a modest 1.5 kg at the end of the study. However, even modest weight loss can improve cardiovascular risk factors. Each kilogram of weight loss is associated with an average decrease in systolic blood pressure of 1.0 to 2.4 mm Hg and a reduction in incident diabetes of 16%. Nevertheless, it is clear that preventing weight regain is extremely challenging. In fact, some observers have asserted that long-term success rates are so low that providing long-term behavioral weight loss treatments may ultimately be futile. However, our results suggest that clinically relevant weight loss maintenance is feasible. At the end of the study, more than 45% of those in the personal-contact intervention were still maintaining at least 4 kg of weight loss, an amount with clear clinical benefits.

Our study results compare favorably with previous trials, including Trials of Hypertension Prevention Phase II (TOHP-II) and STOP Regain. In TOHP-II, an intensive behavioral weight loss intervention was followed by less intensive intervention for a total of 3 years. Only 43% of study participants lost 4 kg or more during the initial intervention compared with more than 60% in our study. Among TOHP-II participants who lost at least 4 kg in the first 6 months of intervention, their mean change in weight at 3 years was −2.3 kg (Nancy Cook, ScD, TOHP Coordinating Center, written communication, November 19, 2007) compared with −4.2 kg in the WLM personal-contact group.

In STOP Regain, 319 adults who reported losing at least 10% of body weight within the previous 2 years were randomly assigned to one of three 18-month maintenance interventions: face-to-face contact, Internet intervention, and control. Despite substantial study differences that might favor weight-loss maintenance (including shorter duration of maintenance intervention, more tailored intervention, and minimal enrollment of minorities), STOP Regain’s findings were similar to those of our study: there was a 2.5-kg weight regain at 18 months in the STOP Regain face-to-face intervention compared with a 3.1-kg regain in the personal-contact intervention of WLM.

An important key to progress in combating the obesity epidemic is the extent to which effective intervention can be widely disseminated. In this regard, interactive technology–based interventions remain promising because of their potential for low-cost dissemination and the extent to which technology is rapidly becoming integrated into communication, learning, and health care. The effect of the WLM interactive technology–based intervention and the STOP Regain Internet intervention were similar: there was no significant difference in long-term regain between the Internet intervention and the control group. At 18 months, participants in the WLM Internet-based group had regained 3.8 kg compared with 4.7 kg in the STOP-Regain Internet group. However, in the WLM interactive technology–based group, weight regain was significantly less than in the self-directed group through 24 months of follow-up. Participants in the interactive technology–based intervention remained...

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**Table 2. Adjusted Weight Change at 30 Months by Treatment Group (N = 1029)**

<table>
<thead>
<tr>
<th></th>
<th>Initial Weight</th>
<th>Self-Directed</th>
<th>Interactive Technology</th>
<th>Personal Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change from entry</td>
<td>96.7 (16.6)</td>
<td>−2.9 (0.4)</td>
<td>−3.3 (0.4)</td>
<td>−4.2 (0.4)</td>
</tr>
<tr>
<td>(kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change from randomization</td>
<td>88.2 (15.8)</td>
<td>5.5 (0.3)</td>
<td>5.2 (0.3)</td>
<td>4.0 (0.3)</td>
</tr>
<tr>
<td>(kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3. Between Group Difference in Weight Change From Randomization, Over Time in Phase 2**

<table>
<thead>
<tr>
<th>Months Since Randomization</th>
<th>6</th>
<th>12</th>
<th>18</th>
<th>24</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ, kg</td>
<td>P Value</td>
<td>Δ, kg</td>
<td>P Value</td>
<td>Δ, kg</td>
<td>P Value</td>
</tr>
<tr>
<td>Interactive technology vs self-directed</td>
<td>−0.8</td>
<td>.003</td>
<td>−1.0</td>
<td>.005</td>
<td>−1.1</td>
</tr>
<tr>
<td>Personal contact vs self-directed</td>
<td>−0.9</td>
<td>.001</td>
<td>−1.6</td>
<td>&lt;.001</td>
<td>−1.8</td>
</tr>
<tr>
<td>Interactive technology vs personal contact</td>
<td>−0.1</td>
<td>.73</td>
<td>−0.6</td>
<td>.11</td>
<td>−0.7</td>
</tr>
</tbody>
</table>

*P values from these models adjust for site, race, sex, race×sex, and weight change during phase 1; a separate model was used for each time point.
Table 4. Adjusted Weight Change at 30 Months Within Race-Sex Subgroups

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Participants</th>
<th>At Entry, Mean (SD)b</th>
<th>Change From Entry, Mean (SE), kgc</th>
<th>At Randomization, Mean (SD)b</th>
<th>Change From Randomization, Mean (SE), kgc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Self-directed</td>
<td>Interactive Technology</td>
<td>Personal Contact</td>
<td>Self-directed</td>
</tr>
<tr>
<td>African American</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>121</td>
<td>108.3 (16.2)</td>
<td>−4.8 (1.3)</td>
<td>−3.0 (1.1)</td>
<td>−4.9 (1.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>267</td>
<td>94.8 (15.2)</td>
<td>−1.8 (0.6)</td>
<td>−1.3 (0.6)</td>
<td>−2.2 (0.6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-African American</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>255</td>
<td>104.0 (15.2)</td>
<td>−3.5 (0.8)</td>
<td>−5.1 (0.8)</td>
<td>−5.7 (0.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>386</td>
<td>89.5 (14.5)</td>
<td>−2.2 (0.6)</td>
<td>−3.0 (0.6)</td>
<td>−3.9 (0.6)</td>
</tr>
</tbody>
</table>

\( ^a \) \( P < .001 \) for all within-treatment-group changes except for African American women in whom \( P = .03 \).
\( ^b \) Unadjusted mean (SD).
\( ^c \) Least-squares mean (SE) adjusted for age, site, race, sex, race × sex, entry weight, and (for change from randomization only) for change in weight in phase 1.

Table 5. Percentage of Participants Who Met Various Criteria for Weight Loss, Overall and by Treatment Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Overall (n = 1029)</th>
<th>Self-directed (n = 341)</th>
<th>Interactive Technology (n = 347)</th>
<th>Personal Contact (n = 341)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintained at least 4 kg weight loss from entry</td>
<td>430 (41.8)</td>
<td>135 (39.5)</td>
<td>142 (40.8)</td>
<td>154 (45.2)</td>
</tr>
<tr>
<td>At or below entry weight</td>
<td>730 (70.9)</td>
<td>227 (66.6)</td>
<td>240 (69.3)</td>
<td>262 (76.7)</td>
</tr>
<tr>
<td>No more than 3% above randomization weight</td>
<td>324 (31.5)</td>
<td>100 (29.3)</td>
<td>101 (29.2)</td>
<td>122 (35.9)</td>
</tr>
<tr>
<td>At least 5% below entry weight</td>
<td>382 (37.1)</td>
<td>116 (33.9)</td>
<td>122 (35.3)</td>
<td>144 (42.2)</td>
</tr>
</tbody>
</table>

\( ^a \) \( P = .003 \) when comparing personal-contact with self-directed groups, and \( P = .03 \) when comparing interactive technology groups.
\( ^b \) \( P = .02 \) when comparing personal-contact with self-directed groups.

Engaged with the Web site, continuing to log-on at least once a week throughout the study, and a large proportion maintained clinically significant weight loss. Given the potential for widespread dissemination at relatively low cost per participant, continued development of interactive technology–based intervention should be a high priority for obesity research.

For both the personal-contact and interactive technology–based interventions, future studies must determine how these maintenance interventions can be improved. It is possible that greater effects may be achieved by providing more tailored intervention. For example, individuals may benefit from different levels of intervention intensity at different times. The personal-contact approach may be superior for some individuals and the interactive technology–based approach for others, or combining elements from both interventions may have additive effects. In addition people attempting to maintain weight loss over the long-term may need to be reenergized, motivated may need to be re-engaged, and social support may need to be re-invigorated. In the interactive technology–based intervention, participants may also need technological enhancements and additional media resources, and they may need occasional personal contacts. Further development of these interventions is needed to increase the proportion of initial weight loss that is maintained and the duration over which it is maintained.

Future intervention development should also consider the fact that weight loss maintenance occurred in a substantial proportion of those in the control group. Similar effects have been seen in control groups in other lifestyle trials, and may simply reflect the fact that the study population is highly selected, highly motivated, and successfully lost weight in phase 1. In addition, there may be an intervention effect associated with the semi-annual data collection visits. However, beyond these factors, identification of predictors of successful weight loss maintenance, regardless of randomized treatment group, may reveal factors that can be emphasized or added to future interventions to improve long-term weight loss maintenance.

The effect of both the personal-contact and interactive technology–based interventions was modest. Future consideration of implementation of these interventions must take into account the cost relative to benefit. But it is important to recognize that to date, there has been little research specifically addressing strategies for maintenance of weight loss, despite the fact that maintenance is the main impediment to long-term weight control. Clearly, these treatment modalities are at the early stages of development. The results of our study lay the groundwork for the development of even more effective approaches to combating and reversing the obesity epidemic, and the results represent significant forward progress.

There were several limitations of the WLM study. First, only individuals who had successfully lost weight in phase 1 were randomized into phase 2. The consequence of this design feature is that the results can only be generalized to the population of successful weight losers. However, this feature was the intent of the study: to compare strategies for maintaining weight loss. Second, there were very few Hispanic participants, another group disproportionately affected by the obesity epi-
In conclusion, the majority of individuals who successfully completed an initial 6-month behavioral weight loss program maintained weight below their entry level after 30 additional months. Monthly brief personal-contact sessions provided modest benefit in sustaining weight loss, whereas an Internet-based intervention provided early but transient benefit. Future research should focus on longer intervention and follow-up, understanding predictors of successful maintenance and further refinement of both personal contact and interactive technology-based interventions.

**REFERENCES**


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**Author Affiliations:** Division of Nephrology (Dr Svetkey and Ms Aicher) and Endocrinology (Dr Lien), Department of Medicine, Duke Hypertension Center and Cardiovascular Medicine, Duke University Medical Center, Durham, North Carolina; Health Education Programs, the Center for Health Research, Kaiser Permanente Northwest, Portland, Oregon; and the San Francisco VA Medical Center (Dr Svetkey, Stevens, Appel, Hollis, Brantley, and Myers). The authors wish to acknowledge the WLM participants that made this study possible. In addition, we would thank the following individuals at each of the participating sites who made substantial contributions to the work but who are not authors: Joel Bronstein, Blondeaner Brown, William Fan, MD, Jeanne Gresko, Tovon Hamilton, Aidan Hysulien, Keely Kelly, Martina King, Yelda Martin, Nidhi Kochar, MD, Tonya Milligan, LaVerne Pruden, LaChanda Reams, Patrice Reams, Fran Ruknedrod, MD, LDN, Sonia Steele, MPH, RD, LDN, and Edward Van Williams, MD, University of North Carolina at Chapel Hill (Dr Svetkey and Myers); Smith, MS); Dietetic Assessment and Food Analysis Core (Dr Kennedy), Chronic Disease Epidemiology and Health Delivery (Dr Harsha), and Nutritional Epidemiology and Dietary Assessment and Counseling (Dr Champagne), PENN Supper Medical Research Center, Baton Rouge, Louisiana; the Welch Center for Prevention, Epidemiology, and Clinical Research, Johns Hopkins University School of Medicine, Johns Hopkins University, ProHealth, Baltimore, Maryland (Drs Appel, Jerome, and Coughlin and Mrs Dalm and Charleston); Division of Prevention and Population Sciences, National Heart, Lung, and Blood Institute, Bethesda, Maryland (Dr Loria); Department of Nutrition, School of Public Health and School of Medicine, University of North Carolina at Chapel Hill (Dr Sam and Dalm); Department of Medicine, University of Texas Medical Branch, Austin (Dr Erlen); and Department of Nutrition Sciences, University of Alabama at Birmingham (Dr Svetkey).

**Author Contributions:** Dr Svetkey had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Svetkey, Stevens, Brantley, Appel, Jerome, Coughlin, and Myers. Acquisition of data: Svetkey, Stevens, Brantley, Appel, Jerome, Coughlin, and Myers. Analysis and interpretation of data: Svetkey, Stevens, Brantley, Appel, Jerome, Coughlin, and Myers. Drafting of the manuscript: Svetkey, Stevens, Brantley, Appel, Jerome, Coughlin, and Myers. Critical revision of the manuscript for important intellectual content: Svetkey, Stevens, Brantley, Appel, Jerome, Coughlin, and Myers. Statistical analysis: Svetkey, Stevens, Brantley, Appel, Jerome, Coughlin, and Myers. Obtained funding: Svetkey, Stevens, Brantley, Appel, Jerome, Coughlin, and Myers. Administrative, technical, or material support: Svetkey, Stevens, Brantley, Appel, Jerome, Coughlin, and Myers.
STRATEGIES TO SUSTAIN WEIGHT LOSS


