A Comparison of Internet and Print-Based Physical Activity Interventions

Bess H. Marcus, PhD; Beth A. Lewis, PhD; David M. Williams, PhD; Shira Dunsiger, BS; John M. Jakicic, PhD; Jessica A. Whiteley, PhD; Anna E. Albrecht, RN, MS; Melissa A. Napolitano, PhD; Beth C. Bock, PhD; Deborah F. Tate, PhD; Christopher N. Sciamanna, MD, MPH; Alfred F. Parisi, MD

Background: Physical activity interventions tailored to individual characteristics and delivered via print produce greater increases in activity compared with nontailored interventions and controls. Using the Internet to deliver a tailored physical activity intervention offers an alternative to print that might be available to larger populations at a lower cost.

Methods: Participants (N=249 adults; mean [SD] age, 44.5 [9.3] years; and mean [SD] body mass index [calculated as weight in kilograms divided by height in meters squared], 29.4 [6.1]) were randomized to 1 of 3 physical activity interventions: (1) motivationally tailored Internet (tailored Internet, n=81), (2) motivationally tailored print (tailored print, n=86); and (3) 6 researcher-selected Web sites available to the public (standard Internet, n=82). Participants in the tailored Internet and tailored print arms received the same tailored intervention content. Participants were assessed at baseline and at 6 and 12 months.

Results: At 6 months, participants in the tailored print arm reported a median of 112.5 minutes of physical activity per week, those in the tailored Internet arm reported 120.0 minutes, and those in the standard Internet arm reported 90.0 minutes ($P=.15$). At 12 months, the physical activity minutes per week were 90.0, 90.0, and 80.0 for those in the tailored print, tailored Internet, and standard Internet arms, respectively ($P=.74$). Results indicated no significant differences between the 3 arms.

Conclusions: The use of tailored Internet, tailored print, and standard Internet as part of a behavior change program increased physical activity behavior similarly. Because the use of the Internet was not different from the print-based intervention, this may be an opportunity to reach more sedentary adults in a more cost-effective way.

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Author Affiliations: The Miriam Hospital and Brown Medical School, Centers for Behavioral and Preventive Medicine (Drs Marcus, Williams, Whiteley, Napolitano, Bock, and Parisi and Ms Albrecht) and Brown University (Ms Dunsiger), Providence, RI; HealthPartners Research Foundation, Minneapolis, Minn (Dr Lewis); Department of Health and Physical Activity, University of Pittsburgh, Pittsburgh, Pa (Dr Jakicic); Departments of Health Behavior and Health Education and Nutrition, The University of North Carolina at Chapel Hill (Dr Tate); and Department of Health Policy, Thomas Jefferson University, Philadelphia, Pa (Dr Sciamanna).

THE SURGEON GENERAL RECommends that Americans engage in regular physical activity to promote living longer and more disease-free lives.[1] Despite this recommendation, only 45% of Americans engage in regular moderate-intensity physical activity (eg, brisk walking), defined by at least 30 minutes per day on most or all days of the week.[2] Physical activity promotion interventions based on behavior change theory have shown efficacy[3,4] and can be delivered through non–face-to-face media to reduce barriers, such as lack of access and time constraints.[5] For example, in 2 randomized controlled trials, print-based, individually tailored, motivational materials were shown to be superior to nontailored, print-based, physical activity materials[6] and to a print-based contact control.[7] Print-based interventions, however, have a number of potential drawbacks, including the delay in mailing participant feedback, the need for participants to store and keep track of printed feedback reports, the lack of immediate interactivity, and the cost of postage and person power necessary to deliver the intervention.

The Internet may be a viable alternative to print-based interventions given the increased use of the Internet among the general public (73% have access to the Internet[8]) and the demonstrated efficacy of using this delivery channel for delivering other tailored interventions.[9] Two studies examining the efficacy of Internet-based physical activity interventions (noncommercial Web sites) among sedentary adults have shown no effects at 3 months relative to a waiting list control group[10] and no increases in physical activity minutes from

baseline to posttest.[11] In both of these studies, Web sites lacked instantaneous interactivity between the user and the Web site, access to a wider range of information through the use of Internet links, change in the Web site over time, and enhanced graphics. Additional limitations included lack of objective exercise assessments (eg, treadmill test), a relatively short intervention, and lack of individual customization of the intervention materials.

The present study addressed the limitations of these studies by testing the efficacy of an Internet-based, individually tailored, physical activity intervention (tailored Internet) relative to a print-based, individually tailored, physical activity intervention (tailored print), which has been shown to be efficacious in previous studies.[6,7] This allows for a test of the delivery medium—print vs Internet—while controlling for intervention content. A secondary objective was to determine the efficacy of the tailored Internet arm in relation to a standard Internet arm (physical activity Web sites available to the public), thus testing tailored vs standard physical activity promotion content while controlling for the Internet medium.

METHODS

STUDY DESIGN

This randomized trial was conducted at 2 sites from January 15, 2003, through June 6, 2006. Participants (N=249) were randomly assigned to 1 of 3 conditions: (1) motivationally tailored Internet (tailored Internet, n=81), (2) motivationally tailored print (tailored print, n=86), and (3) 6 researcher-selected Web sites available to the public (standard Internet, n=82).

Before randomization, participants completed the following: (1) telephone screening to establish eligibility, (2) an orientation session to obtain more information about the study, (3) a measurement session (ie, body composition measures and resting electrocardiogram), and (4) an exercise test. A randomization session was then scheduled, in which participants learned their treatment assignment by opening an envelope created and administered to them by an individual not involved in assessment. Randomization was stratified on sex and baseline level of motivation and based on an urn model.[12] This model allowed us to keep strata balanced without having to use fixed block size. The within-strata randomization assignments were generated in advance by a computer algorithm.

PARTICIPANTS

Healthy sedentary (≤90 minutes of physical activity each week) men and women 18 years and older were recruited, primarily through newspaper advertisements, from the Providence area (74.7% of the sample), and to increase the racial diversity of our sample, from Pittsburgh (25.3% of the sample). Exclusion criteria included the following: (1) a history of coronary or valvular heart disease, hypertension, diabetes mellitus, chronic obstructive pulmonary disease, stroke, osteoarthritis, orthopedic problems that would limit treadmill testing, or any other serious medical condition that would make physical activity unsafe or unwise; (2) consuming 3 or more alcoholic drinks per day on 5 or more days of the week; (3) current or planned pregnancy; (4) planning to move from the area within the next year; (5) current suicidal ideation or psychosis; (6) current clinical depression and/or hospitalization because of a psychiatric disorder in the past 6 months; and (7) taking medication that may impair physical activity tolerance or performance and/or previous participation in one of our exercise trials. Participants read and signed a consent form approved by both sites' institutional review boards.

ASSESSMENT

The primary dependent variable was minutes of physical activity per week, which we assessed using an interviewer-administered 7-day physical activity recall (PAR).[13,14] Participants also completed a graded submaximal treadmill exercise test using a Balke[15] protocol, with 2-minute stages beginning at 4.8 km and 2.5% grade. The speed remained constant throughout the test, and the grade increased 2.5% every 2 minutes, with an end point of 85% of age-predicted maximum heart rate. The electrocardiogram and blood pressure were assessed throughout the test and recovery. The American College of Sports Medicine[16] pretest instructions and absolute and relative indications for test termination were followed. Functional capacity, expressed as estimated oxygen consumption per unit time ($\dot{V}O_2$) at 85% of predicted maximum heart rate (measured in milliliters per kilogram per minute) was used to determine changes in fitness. Assessments were conducted at baseline and at 6 and 12 months.

TREATMENT

Tailored Internet Arm

Participants in the tailored Internet arm were prompted to log into the study Web site, which included evidence-based physical activity educational and motivational materials,[6] a goal-setting function, and links to other sites. E-mail prompts to access the Web site were sent weekly during month 1, biweekly during months 2 and 3, and monthly during months 4 through 12. In addition, participants were prompted via e-mail to complete monthly questionnaires online and received immediate tailored feedback according to their responses. The feedback was based on the transtheoretical model (ie, stage of readiness to change) and social cognitive theory (eg, increasing confidence).[17-19] Participants also set physical activity goals and completed online physical activity logs documenting their daily physical activity. Educational materials and "tips" for adopting and maintaining physical activity were also included on the Web site. Participants were paid $10 each month as partial compensation for their time spent completing the questionnaires.

Tailored Print Arm

Participants randomized to the tailored print arm received the same information, behavioral strategies, and monthly payment on the identical timeline as the tailored Internet arm; however, the intervention was delivered through the mail instead of through the Internet. For example, participants were prompted to complete questionnaires through the mail rather than through the Internet and completed physical activity logs via paper-and-pencil calendars. Participants were mailed their tailored report following our receipt of the questionnaires.

Standard Internet Arm

Participants in the standard Internet arm completed questionnaires and physical activity logs at the same intervals as the other 2 groups but did not receive the tailored feedback reports. Instead, participants accessed a study Web page that contained links to 6 physical activity Web sites available to the public,

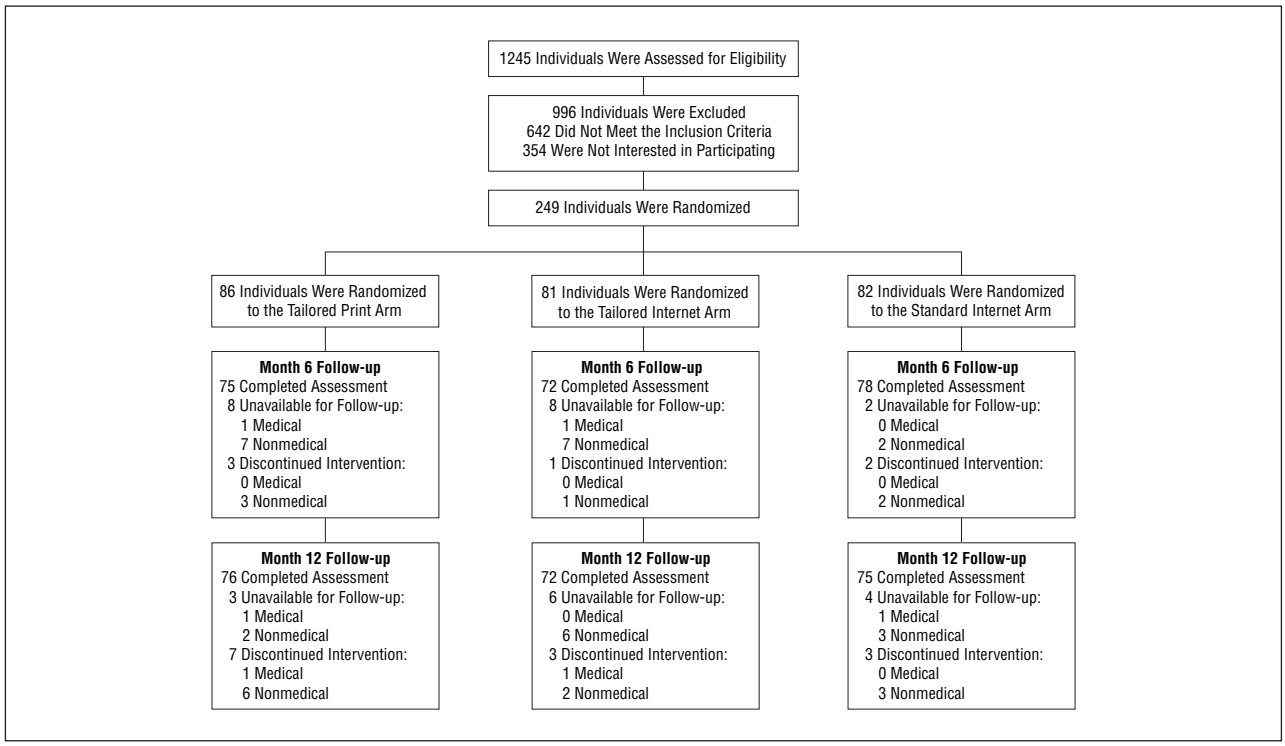

Figure 1. Participant flowchart. Standard Internet indicates physical activity Web sites available to the public; tailored Internet, an Internet-based, individually tailored, physical activity intervention; and tailored print, a print-based, individually tailored, physical activity intervention.

including the American Heart Association (Just Move), Shape Up America, Mayo Clinic Fitness and Sports Medicine Center, American Academy of Family Physicians (physical activity section), American Council on Exercise, and American College of Sports Medicine health and fitness information. We selected these Web sites based on reputation, accuracy of information, inclusion of some assessment tools, and inclusion of some behavioral (eg, overcoming barriers) and cognitive (eg, physical activity benefits) strategies. Based on a review of free Web sites available to the public published subsequent to the start of this trial, Just Move from the American Heart Association had the greatest use of behavior change theory, including social cognitive theory and the transtheoretical model.[19]

STATISTICAL ANALYSES

The sample size for the present study was based on the assumption of a 30-minute difference at 12 months between the tailored Internet and the tailored print arms, assuming a 1% type I error rate (α) and 90% power. Baseline characteristics were compared across groups using an analysis of variance for the continuous variables and Pearson χ^2 tests for the categorical variables. The primary dependent variable for analysis was median change in minutes of physical activity per week, as reported on the 7-day PAR, from baseline to 6 months and from baseline to 12 months (ie, change scores). The PAR was positively skewed, so summaries were written in terms of medians and interquartile ranges. Similarly, change scores were computed for the fitness measure (estimated peak $\dot{V}O_2$ at 85% of age-predicted maximum heart rate) from baseline to 6 months and from baseline to 12 months. The fitness measures were symmetrically distributed and, therefore, we reported means and standard deviations. We conducted an intent-to-treat analysis and, in the event of missing data, we carried forward baseline values. Quantile regression was used to compare change in the PAR across the 3 intervention arms, controlling for baseline levels of activity. We used analysis of covariance to compare changes in fitness variables.

RESULTS

PARTICIPANTS

A total of 1245 potential participants completed a telephone screening interview to determine eligibility (**Figure 1**). Of these participants, 642 were ineligible (380 had health conditions, 151 were too active, 34 were not able to access the study Web site, 11 did not complete the telephone screening interview, and 66 had other reasons). Three hundred fifty-four participants failed to attend all of the prerandomization assessment sessions. The remaining 249 participants were randomized to 1 of the 3 conditions. There were no significant differences between the 3 study arms on the demographic and baseline variables (**Table 1**).

PRIMARY DEPENDENT VARIABLE: 7-DAY PAR INTERVIEW

Follow-up (ie, the PAR interview) was completed by 89.2% of participants at 6 months and by 87.1% of participants at 12 months. There was no differential dropout between the groups. At 6 months, participants in the tailored print arm reported a median of 112.5 minutes of physical activity per week, those in the tailored Internet arm reported 120.0 minutes, and those in the standard Internet arm reported 90.0 minutes ($P = .15$). At 12 months, the physical activity minutes per week were 90.0,

Table 1. Baseline Characteristics by Group*

Characteristic	Tailored Print Group (n = 86)	Tailored Internet Group (n = 81)	Standard Internet Group (n = 82)	*P* Value†
Age, y‡	44.5 (9.6)	44.5 (9.0)	46.3 (9.4)	.46
Female sex	83.7	81.5	82.9	.93
White race	77.9	82.7	84.1	.55
Non-Hispanic or non-Latino ethnicity	90.7	91.4	92.7	.90
Married	69.8	63.0	55.6	.16
Employed	80.2	90.0	89.0	.13
College graduate (or doing postgraduate work)	72.1	64.2	64.6	.47
Total annual household income >$50 000	57.0	58.0	53.7	.84
Body mass index‡§	29.1 (6.2)	29.7 (6.5)	29.5 (5.5)	.84
Moderate to vigorous PA, min/wk‖	0.0	0.0	10.0	.73
Expenditure, kcal/kg per d‖	32.1	32.1	32.0	.62
Estimated $\dot{V}O_2$ at 85%, mL/kg per min‡	24.8 (6.6)	25.5 (6.8)	24.3 (6.1)	.49

Abbreviations: PA, physical activity; standard Internet, physical activity Web sites available to the public; tailored Internet, Internet-based, individually tailored, physical activity intervention; tailored print, print-based, individually tailored, physical activity intervention; $\dot{V}O_2$, oxygen consumption per unit time.
*Data are given as percentage of each group unless otherwise indicated.
†For differences between groups.
‡Data are given as mean (SD).
§Calculated as weight in kilograms divided by height in meters squared.
‖Data are given as median.

90.0, and 80.0 for those in the tailored print, tailored Internet, and standard Internet arms, respectively ($P=.74$). Results indicated no significant differences between the 3 arms on the change scores from baseline to 6 months and from baseline to 12 months (**Figure 2**). At 6 months, 37.2% of the tailored print arm participants, 44.4% of the tailored Internet arm participants, and 36.6% of the standard Internet arm participants met the national guidelines for physical activity (defined as at least 150 minutes of physical activity per week, $P=.52$). At 12 months, the percentages were 32.6%, 39.5%, and 30.5% for the tailored print, tailored Internet, and standard Internet arm participants, respectively ($P=.45$). χ^2 Tests did not show any differences between groups (**Table 2**).

Most physical activity minutes reported were in the moderate-intensity range (90.9% at baseline, 83.8% at 6 months, and 84.4% at 12 months), and the most commonly reported type of activity was walking. Specifically, the percentages of physical activity bouts that included walking were 45.9% at baseline, 64.3% at 6 months, and 62.8% at 12 months. There were no differences between treatment arms with respect to walking at any of the time points. Kilocalorie expenditure (kilocalories per kilogram per day) was calculated from the PAR interview.[20] Because the kilocalorie expenditure data were skewed, we used medians. We found no significant differences between groups at any of the time points on kilocalorie expenditure (Table 2).

SECONDARY DEPENDENT VARIABLE: EXERCISE PERFORMANCE

Participants exhibited a 5.2% improvement in fitness from baseline to 6 months and a 5.9% improvement from baseline to 12 months for functional capacity, as expressed by estimated $\dot{V}O_2$ at 85% of predicted maximum heart rate (measured in milliliters per kilogram per minute). There were no significant differences between the 3 arms on the change scores (baseline to 6 months and baseline to 12 months) on $\dot{V}O_2$ (Table 2). Improvements in $\dot{V}O_2$ significantly correlated with changes from baseline to 12 months on the PAR interview ($r=0.21$, $P=.001$).

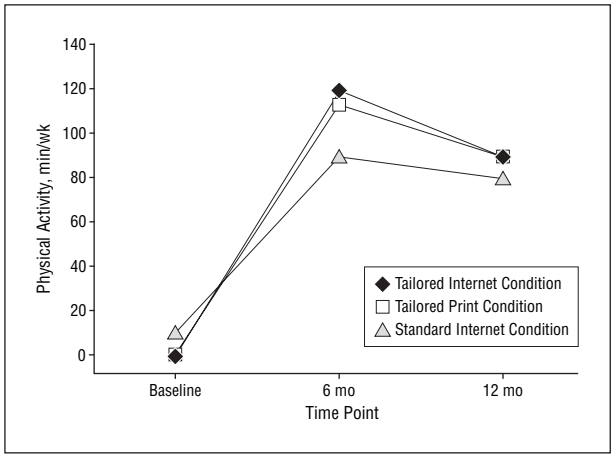

Figure 2. Median physical activity by condition and time point. Conditions are described in the legend to Figure 1.

INTERNET USE

The number of Internet logins completed by the 2 Internet-based treatment conditions was positively skewed and, therefore, summaries are written as medians. Using the Wilcoxon rank sum (Mann-Whitney) test, we found that the tailored Internet arm logged onto the study Web site significantly more times during the study compared with the standard Internet arm (50 vs 38; $z=-2.21$, $P=.03$). We used quantile regression to examine the association between the number of logins and change in the PAR. To make the number of logins more symmetric, we included the natural log transformation as a covariate in our model. An increase in the log transformation of the

Table 2. Outcomes by Group*

Variable	Tailored Print Group (n = 86)	Tailored Internet Group (n = 81)	Standard Internet Group (n = 82)	*P* Value†
Moderate to vigorous PA, min/wk				
6 mo	112.5	120.0	90.0	.15
12 mo	90.0	90.0	80.0	.74
Expenditure, kcal/kg per d				
6 mo	32.7	32.5	32.6	.94
12 mo	32.7	32.5	32.5	.62
Those reporting at least 150 min/wk of PA, %				
6 mo	37.2	44.4	36.6	.52
12 mo	32.6	39.5	30.5	.45
Estimated $\dot{V}O_2$ at 85%, mL/kg per min‡				
6 mo	25.8 (6.8)	26.5 (6.6)	25.4 (6.6)	>.99
12 mo	26.2 (6.9)	26.1 (6.9)	25.7 (6.0)	.31

Abbreviations: See Table 1.
*Data are given as median unless otherwise indicated.
†For between-group differences in change from baseline.
‡Data are given as mean (SD).

number of logins was associated with an increase in median change in physical activity from baseline to 12 months, controlling for treatment group and baseline physical activity (B=34.32; 95% CI, 14.33-54.31).

COMMENT

Contrary to our hypothesis, we found no significant differences in the amount of change between the tailored arms (tailored Internet and tailored print) and the standard Internet arm. There are several possible reasons why the standard Internet arm performed better than expected. First, the 6 Web sites for the standard Internet arm were selected by doctoral-level researchers and included content important for behavior change. Second, all participants were prompted to complete physical activity logs. This possibly contributed to the equity across groups given self-monitoring techniques have yielded large effect sizes in physical activity interventions.[21] Finally, all participants completed multiple questionnaires assessing physical activity constructs. Perhaps completing these questionnaires increased participants' awareness of their physical activity patterns and influenced physical activity participation. Therefore, a limitation of the present study is the lack of a pure contact control arm.

To better understand how the interventions in our present study may have performed relative to a contact control arm, we compared our findings with those of a recent study[7] with a similar sample in which a print intervention, identical to that in our present study, was superior to a contact control arm in self-reported physical activity over 12 months. Specifically, we compared the Internet arms in our present study with the control arm in this previous study while subtracting out study effects to reduce the risk of confounding. Results indicated greater changes in physical activity from baseline to 12 months in the Internet arms of the present study compared with the control arm of the previous study (*P*=.01 for the tailored Internet arm and *P*=.004 for the standard Internet arm). However, limitations of this secondary analysis include the loss of benefits regarding randomization and the use of different study populations.

A second unexpected finding of the present study was that the tailored Internet arm did not differ from the tailored print arm, which has been shown to be efficacious in previous studies.[7] This is an important finding given that the Internet has the potential to reach much of the sedentary population in a cost-efficient manner. Unlike print-based arms, increasing the number of Internet arm participants does not significantly increase the cost of the intervention; thus, this type of intervention can have a broad reach.

Strengths of the study include examination of the effect of an individually tailored, behaviorally oriented, Internet-based intervention on physical activity behavior change. Previous studies[10,11] have examined nontailored Web sites, included small sample sizes with inadequate power, and lacked links to various Web pages within the study Web site. Other strengths of the present study are the randomized design, the inclusion of an objective assessment of fitness (ie, the exercise test) that mirrored the findings obtained from our self-report measure (ie, 7-day PAR interview), and an ethnically and racially diverse sample (23.7% racial-ethnic minorities).

There were several limitations to the study. First, participants were highly educated (72.1% were college educated), were high socioeconomic status (57.0% had an annual household income of >$50 000) study volunteers, and consisted mostly of women (83.7%). Therefore, results may not generalize to the overall population. In addition, potential participants with certain medical conditions, such as diabetes mellitus and hypertension, were excluded because of the additional medical oversight needed for these individuals. Future effectiveness studies should examine the effects of similar interventions among these individuals. Second, although we included several features of the Internet that were not included in previous studies, such as immediate tailored feedback and interactive goal setting, we did not use the full capability of the Internet. For example, techniques such as encourag-

ing peer-to-peer support through chat rooms or message boards and including professional support through personalized e-mails have been effective in the weight loss literature,[9] but were not used in the present study to control for intervention content available in the tailored print condition. Such features would provide intratreatment social support that has been shown to be important in behavior change interventions.[22,23] Third, it is unclear if participants maintained their treatment gains after 12 months and if print or Internet programs are more likely to foster physical activity maintenance after contact with intervention staff has ceased.

In summary, our findings indicate that all of the interventions studied significantly increased physical activity behavior among sedentary adults. Because there were no significant differences across groups, it is unclear if the interventions, a research procedure (eg, completion of questionnaires), and/or a variable in the environment influenced the physical activity increase. However, our findings are important given the potential of the Internet for widespread dissemination and the potential to reach many sedentary individuals. In 2006, 147 million US adults (73% of the population) were Internet users.[8] If sedentary individuals are at least as likely as active individuals to use the Internet, this means roughly 80 million underactive adults in the United States are online and might be reached via Internet-based interventions. Future studies should examine the effectiveness of tailored Internet interventions disseminated in "real-life" settings that are void of the research components present in our efficacy trial.

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Correspondence: Bess H. Marcus, PhD, The Centers for Behavioral and Preventive Medicine, The Miriam Hospital and Brown Medical School, 1 Hoppin St, Coro Bldg, Suite 500, Providence, RI 02903 (bmarcus@lifespan.org).
Author Contributions: *Study concept and design:* Marcus, Lewis, Jakicic, Whiteley, Albrecht, Napolitano, Bock, Tate, Sciamanna, and Parisi. *Acquisition of data:* Marcus, Lewis, Williams, Jakicic, Albrecht, and Parisi. *Analysis and interpretation of data:* Marcus, Lewis, Williams, Dunsiger, Jakicic, Whiteley, Albrecht, Sciamanna, and Parisi. *Drafting of the manuscript:* Marcus, Lewis, Williams, Dunsiger, Jakicic, Whiteley, Albrecht, Bock, Tate, and Parisi. *Critical revision of the manuscript for important intellectual content:* Marcus, Lewis, Williams, Dunsiger, Jakicic, Whiteley, Napolitano, and Sciamanna. *Statistical analysis:* Lewis and Dunsiger. *Obtained funding:* Marcus, Lewis, Jakicic, Whiteley, Napolitano, and Bock. *Administrative, technical, and material support:* Marcus, Albrecht, Napolitano, Tate, and Sciamanna. *Study supervision:* Marcus, Jakicic, Albrecht, and Parisi.
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