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The D-Net diabetes self-management program: long-term implementation, outcomes, and generalization results

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Abstract

Background. A prerequisite to translating research findings into practice is information on consistency of implementation, maintenance of results, and generalization of effects. This follow-up report is one of the few experimental studies to provide such information on Internet-based health education.

Methods. We present follow-up data 10 months following randomization on the "Diabetes Network (D-Net)" Internet-based self-management project, a randomized trial evaluating the incremental effects of adding (1) tailored self-management training or (2) peer support components to a basic Internet-based, information-focused comparison intervention. Participants were 320 adult type 2 diabetes patients from participating primary care offices, mean age 59 (SD = 9.2), who were relatively novice Internet users.

Results. All intervention components were consistently implemented by staff, but participant website usage decreased over time. All conditions were significantly improved from baseline on behavioral, psychosocial, and some biological outcomes; and there were few differences between conditions. Results were robust across on-line coaches, patient characteristics, and participating clinics.

Conclusions. The basic D-Net intervention was implemented well and improvements were observed across a variety of patients, interventionists, and clinics. There were, however, difficulties in maintaining usage over time and additions of tailored self-management and peer support components generally did not significantly improve results.

Keywords: Self-care; Diabetes mellitus, Non-insulin-dependent; Nutrition; Internet; Maintenance; Social support; Randomized control trial; Health education

Introduction

The long-term effects of intervention is a key issue in diabetes education, as well as for related self-management issues such as weight loss, physical activity, and smoking cessation. A recent NIH conference to address these issues concluded that there is a "need for new models of population health behavior change . . ." [1] and recent reports have documented the difficulty in sustaining initial effects of diabetes education [2]. With efforts to control health care costs resulting in fewer staff being required to do more things, consistent delivery of interventions has also become an increasing challenge [3].

These issues of implementation and long-term outcomes, along with generalization of treatment effects, are major concerns for health care delivery systems, purchasers, and consumers [4]. Unfortunately, there has been a disconnection between much of the research conducted on health care improvement, including diabetes self-management research, and these issues [5–7]. In an effort to control "extraneous factors" and to conduct tightly controlled studies with high internal validity, researchers have often opted to simplify the complexities of practice by doing such things as studying only patients without any other chronic conditions or disease complications and only those willing, able, and sufficiently motivated to participate in a series of intensive group meetings [8,9]. Similarly, at the organizational and

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interventionist level, the vast majority of research has been conducted in specialized tertiary care centers that have considerable implementation resources and interventions that are conducted by expert staff.

There is nothing inherently wrong with this type of "efficacy" research, which is designed to evaluate interventions under optimal conditions [10]. It is problematic, however, when these become the only types of outcome studies conducted or reported, when meta-analyses and evidence-based literature reviews are based predominantly or solely on these types of studies, and when the results are assumed to translate into "real-world" practices of complicated, less motivated patients, practitioners who have many competing demands, and systems having far fewer resources. The end result is that much research ends up being based on unrepresentative patients [6], conducted in unrepresentative settings, implemented by experts who specialize in delivering intensive, complex interventions.

The few published research reports on Internet-based interventions have been on participants with existing Internet access. Although the "digital divide" is narrowing in several, but not all ways [11,12], it is still older (e.g., diabetes type 2) patients who have limited Internet access at home [13,12]. One of the innovative goals of our project was to study an Internet-based diabetes self-management intervention with a representative sample of older primary care patients who had limited or no previous Internet experience. Although Internet-based interventions have been evaluated for other chronic illnesses and behavior change targets [14–16], this project was to our knowledge the first controlled trial of an Internet-based self-management intervention for type 2 diabetes.

Our research group has begun investigating some of the challenges noted above and to evaluate the generalizability of our findings, using what we term the RE-AIM evaluation framework [3,17]. RE-AIM is an acronym for Reach, Efficacy/Effectiveness, Adoption, Implementation, and Maintenance of interventions (www.re-aim.org). Reach and Efficacy (or Effectiveness depending on the study) are assessed at the individual or patient level and refer to the representativeness of patients who participate in a program and the impact of the intervention (including potential negative outcomes), respectively. Adoption and Implementation are assessed at the provider or health care setting level and are reported far less frequently than are individual level outcomes [18,19]. Adoption concerns the participation rate and representativeness of settings (e.g., medical offices) that participate in a program or evaluation, and Implementation refers to the consistency with which different intervention components are delivered (by different intervention agents) over time. Finally, Maintenance has indices at both the individual and the setting level. Individual level Maintenance refers to the longer-term effects on patient outcomes, and setting level Maintenance refers to whether an innovation or program is retained or becomes institutionalized (vs dropped) over time [19,20]. We think that information on the above dimensions is necessary to evaluate the potential of interventions for translation to practice.

We have previously reported on the Reach (62%) participation of a representative sample of primary care type 2 diabetes patients; Adoption (16 of 18 providers and all of the clinics approached agreed to participate); and short-term Effectiveness of our D-Net self-management intervention to enhance diabetes dietary self-management [21,22]. The purposes of the present paper are to report on the longer-term implementation across interventionists, on program usage over time and across conditions, on 10-month follow-up results on behavioral, biologic, and psychosocial outcomes, and on generalization of results across patients from the different clinics participating in the study.

Methods

Design overview

A randomized design was employed to evaluate the effects at 10 months following randomization of adding Tailored Self-Management (TSM) training and Peer Support (PS) maintenance components to a basic information-based Internet nutrition intervention. The basic intervention condition received by all participants involved having a computer dedicated to the Internet project placed in their home, periodic on-line assessment, and access to a user-friendly, easy to navigate, information-based diabetes self-management website.

Recruitment and participants

Feil et al. [21] have described recruitment procedures, participation, and patient characteristics. In summary, a broad and representative cross-section of type 2 primary care patients (150 males and 170 females) who were patients of 16 physicians at 6 different medical offices participated. All participants were living independently; had a telephone; read and wrote English; were diagnosed with type 2 diabetes for at least 1 year, and were not planning to move out of the area during the next year. Those patients taking insulin met the Welborn criteria [23] for type 2 diabetes based on age at diagnosis, BMI, and age of insulin initiation. Within the eligible patients from each provider, participants were randomly assigned to one of four conditions. The average age of participants was 59 years (SD = 9.2), they had been diagnosed with diabetes an average of 8 years (92% had been diagnosed for 2 or more years), and most patients had one or more chronic illnesses in addition to diabetes. Eighty-three percent had either no or extremely limited Internet experience prior to the study. Participant characteristics are described in more detail in McKay et al. [22], but these patients were generally representative of type 2 patients in the communities in which they lived. With one exception, there were no baseline differences between con-

Table 1
Treatment components by intervention condition

Basic information	Tailored self-management[a]	Peer support[a]
1. In-home training for approximately two visits of 1–2 h each	1. Access to on-line professional one-on-one advice and encouragement 2×/week	1. Exchange diabetes-related information, coping strategies, and emotional support with peers
2. Library of articles on diabetes and information from American Diabetes Association	2. Feedback on dietary intake and collaborative goal setting	2. Professionally monitored forum
3. Automated dietary goal setting	3. Tailored strategies for overcoming barriers	3. Series of five electronic newsletters
4. Quarterly on-line assessments	4. Dietitian "Question and Answer" conference	
	5. Blood glucose and dietary databases and graphical feedback	

[a] Participants in the Tailored Self-Management and the Peer Support conditions also received all of the components in the Information Only condition.

ditions on either demographic or dependent variables [22]. Participants in the Tailored Self-Management conditions did have significantly lower levels of total cholesterol than those not in these conditions, but these baseline differences were adjusted in the outcome analyses.

Intervention conditions

Theoretical framework

The intervention components were grounded in two theoretical frameworks. Self-efficacy theory [24] provided the theoretical framework for Tailored Self-Management. Self-efficacy refers to a person's appraisal that certain behaviors can be performed successfully. Intervention components that called for participants to work collaboratively with a coach to set goals, self-monitor, and change dietary behavior were intended to bolster participants' confidence that they could change behaviors that would improve their health. Improved self-efficacy, in turn, has been associated with adherence to a variety of treatment regimens [24], including diabetes [25]. The TSM intervention addressed self-efficacy through Internet-mediated modeling, accomplishment of graduated goals, and development of individual and situation specific problem-solving strategies.

Social support theory was the theoretical framework for the Peer Support intervention. An enormous literature on social support's effects on health has been amassed over the past 30 years [26,27]. Several hypothetical mechanisms have been proposed to explain those effects [28,29]. First, individuals who perceive themselves to have adequate social support experience less negative affect such as depression. Reduced negative affect is thought to result in better immune system functioning, less physical stress from high levels of emotional arousal [26], and perhaps improved metabolic control [30]. In addition, individuals who have social support are thought to take better care of themselves (eat properly, sleep well) than persons who are socially isolated [29].

Information only

Participants in the Information Only condition had computer access to an extensive number of articles on topics of medical, nutritional, and lifestyle aspects of diabetes. All these articles gave information only and did not systematically instruct participants or provide individually tailored recommendations for changing dietary practices or other behaviors. They also completed assessments on-line and received automated dietary change goals based upon their current dietary levels. Each participant received in-home training in use of the computer of approximately two to three visits of 1–2 h each. Participants in the other conditions received all of the above and, in addition, the other materials and activities described below.

Tailored self-management training

Participants in the TSM conditions had computer-mediated access to a professional "coach" who had expertise in providing dietary advice to diabetes patients. Participants worked with their on-line coach and resources on our website to reach their dietary goals. These dietary goals were negotiated with participants' on-line coaches, whom they could access twice per week throughout the intervention period. The coach suggested tailored strategies for overcoming barriers and provided tips, information, and encouragement to assist the participants in meeting their goals. Participants also had access to an on-line "Dietitian Question and Answer" conference that covered specific topics such as "Reading Food Labels" and "Using Low-Fat Substitutes." They also could enter and receive graphical feedback on their pattern of blood glucose levels for different periods of each day (e.g., breakfast, dinner, before and after exercise). In the second half of the intervention period, coaches focused on increasing consumption of fruits and vegetables in such conferences as "Increasing Your Intake of Fruits and Vegetables." Participants accessed a personal database where they could enter information on their daily intake of fruits, vegetables, and saturated fat. All data entered could be graphically displayed in real time for feedback to participants as a way to support their dietary change efforts (Table 1).

Peer support

Individuals in the PS conditions participated in several activities that provided them with opportunities to exchange

diabetes-related information, coping strategies, and emotional support. The main activity area, the Diabetes Support Conference, was a peer-directed (but professionally monitored) forum for participants to interact with one another in a safe, supportive setting where participants were encouraged to express their concerns, successes, and frustrations with their day-to-day coping with diabetes. Group members posted messages that other members could read and answer.

A structured support conference area called Focus Forums was more topic-oriented than the Diabetes Support Conference. Periodically, the research staff introduced specific diabetes-related topics to stimulate peer group discussion. For example, topics included "Denial? Not Me!," "Getting the Best of Stress," and the "Ebb and Flow of Living with Diabetes." In addition to these support activities, participants could also engage in real-time live chat discussions. Those in the PS conditions also received electronic newsletters focused on community resources and support five times throughout the study. The newsletters contained information on local restaurants that provided low-fat menu options; strategies for talking with doctors; advice on using media (e.g., books, TV, and videos) for supporting diabetes self-management; and descriptions of real life success stories from others with diabetes.

Measures

Outcomes

Effectiveness was evaluated by improvement from baseline to the final assessment 10 months later using multiple measures within each of three different domains: behavioral, biological, and psychosocial outcomes. Self-report measures were completed primarily by mail or in person and collected by research staff. Baseline measures were collected immediately prior to randomization.

Dietary outcomes

Dietary outcomes were assessed by improvements on the Kristal Fat and Fiber Behavior (FFB) scale and the Block/NCI Fat Screener. The FFB is a validated 20-item scale assessing behavior patterns related to low-fat eating. Previous research has found this scale to be reliable, sensitive to change, and correlating well with much longer "gold standard" measures such as food records and food frequency questionnaires [31–33].

The Fat Screener is a brief 15-item dietary questionnaire [34] that is a subset of items from the 98-item Full Block Food History questionnaire that contributed the most to fat intake in a nationally representative sample. This instrument correlates highly with the Kristal FFB [31] and with criterion measures of percentage of calories from fat and from saturated fat derived from the Full Block National Cancer Institute instrument as well as 4-day food records [33].

Other behavioral outcomes

These were assessed by a measure of the percentage of diabetes care guidelines that patients met and a measure of physical activity. Diabetes care was measured by a composite of care recommendations from the American Diabetes Association Provider Recognition Program [35]. This was a summary of how many of the 11 criteria that the patient met (e.g., dilated eye exam within the past year; foot exam within past year; advised to stop smoking) which has been used successfully in previous research [36,37].

Physical activity was measured by the Physical Activity Scale for the Elderly. This previously validated instrument [38] measures the frequency in the past 7 days of (a) 30 minutes of moderate physical activity, (b) a specific exercise session (such as swimming, walking, biking) other than what the participant does around the house or as part of work, and (c) a walk outside his or her home or yard (or on a treadmill).

Biological outcomes

Biological outcomes were evaluated by changes in HbA_{1C} and lipid ratios. HbA_{1C} determination was based on turbidimetric immunoinhibition using hemolyzed whole blood, with the Hitachi 717 (Boehringer Mannheim Corp.). Normal values using this assay range from 5.1 to 6.1. Improvement in lipids was measured by changes in the ratio of total cholesterol to HDL [39] which has been found to be a better predictor of heart disease than total cholesterol.

Psychosocial outcomes

These were assessed by the Diabetes Support Scale and the Center for Epidemiologic Studies–Depression scale (CES-D) [40]. The Diabetes Support Scale (DSS) is a 12-item scale for assessing perceived social support [41,42]. In a pilot study of the D-Net site, the DSS had an internal consistency reliability of 0.92 and was correlated with several validity indicators [41]. In the present study, the DSS showed an internal consistency reliability of 0.90.

The CES-D is a widely used self-report measure that is designed to assess depressive symptomatology in the general population [40]. Over a variety of studies it has shown internal consistency reliabilities over 0.8 and test–retest reliabilities over 0.5 for follow-up periods that ranged from several weeks to several months [43].

Implementation and process measures

These included delivery of intervention components and participant usage of the website. Automated tracking of participant website usage via logons represents a unique aspect of Internet-based research and provides a behavioral index of program usage. Website log files were generated for each participant's website session recording all pages viewed, areas of the website visited, and average rate of logons per time frame throughout the study.

Analyses

Descriptive analyses using means, standard deviations and distributions were used to clean the data, see whether transformations were needed, and describe the overall level of improvement and implementation. Paired *t* tests were used to evaluate overall change from baseline to the 10-month follow-up assessment. Multivariate analyses of covariance (MANCOVA) were used to compare the magnitude of changes from baseline to 10 months later across conditions, intervention agents, and office settings. Where the multivariate test of effect for a domain (dietary, physical activity and guidelines, biologic outcomes, or psychosocial outcomes) was significant, univariate tests were used to assess the source of the effect.

Results

Attrition

One-year follow-up data were collected on 82% of the randomized participants (differences among conditions, ns). Analyses of the characteristics of those present vs those not present at follow-up revealed no significant main effects or interactions with treatment condition on any of several baseline characteristics (two-way ANOVAs on demographics and medical characteristics). Therefore, remaining analyses are reported on participants having data at 10 months.

Implementation

Given that this was a "real world" study of older, representative primary care patients, intervention components were implemented extremely consistently across conditions and across different interventionists. All participants set initial dietary goals via an on-line interactive assessment upon entering the program. Participants were then reassessed on-line at 3 and 6 months to update their dietary goals and, for those in the TSM condition, an on-line coach was available to collaboratively discuss and refine their dietary goals and barrier-based coping strategies with them. These activities had 100% implementation rates. Similarly, for those participants in the PS condition, which focused on support for dietary behavior change and general diabetes self-management, five on-line D-Net newsletters were posted to the website at roughly 2-month intervals. These activities also had 100% implementation rates.

Given the often cited concerns [44] about the posting of medical misinformation by users of web-based support groups, we monitored all messages in the PS condition but found no evidence of incorrect medical information being offered by participants during the 10-month period. Moreover, given this novice group of users, we were encouraged that we needed to intervene on only two occasions to remind some overly enthusiastic members of community rules.

Usage

Website use measured by logons varied highly across time and conditions, despite our efforts to keep all participants involved with the website throughout the intervention. As seen in Fig. 1a and b, there was consistently greater website use over the first 3-month period for all conditions. Usage dropped off gradually across all conditions during the second 3 months, with the lowest usage rates occurring during the 7- to 10-month period. In addition, across all time periods of the study both the PS and the TSM conditions resulted in more frequent logons than those not receiving these interventions, with the PS conditions resulting in the most frequent website usage at all time points.

Long-term outcomes

Ten-month assessment results revealed significant improvements from baseline across conditions on the majority of outcomes (Table 2), and the magnitude of these improvements was approximately the same as that seen at earlier follow-ups [22]. Improvements were largest for the targeted dietary outcomes of the Kristal FFB and the Block Fat Screener, next largest for the psychosocial outcomes (perceived barriers and support; depression scores), and more modest for other behavioral outcomes (e.g., improvements in medical care) and biological outcomes (e.g., 12 mg/dl reduction from baseline in cholesterol).

As can be seen in Table 3, the pattern of changes generally favored the TSM and PS conditions compared to conditions not receiving these components. However, multivariate analyses to evaluate potential differences between treatment conditions failed to reveal significant incremental effects of either TSM or PS at the 10-month assessment, with the exception of the psychosocial outcomes. Follow-up univariate analyses revealed that this overall effect was due to the PS conditions producing significantly greater improvement on the Diabetes Support scale than among those not in these conditions. Because of the relatively good baseline levels on some measures such as HbA1c, we also conducted analyses of "differential outcome by baseline level" [45,46] in which we included interaction terms between treatment and baseline level on the relevant dependent variable (using median splits). These analyses failed to reveal any differential effects.

Generalization

A series of ANCOVA analyses to evaluate potential differential outcomes or treatment interactions with (a) interventionist, (b) clinic, and (c) patient gender, age, race/ethnicity, and years having diabetes were generally nonsignificant. There were no significant interaction effects involving interventionists or demographic variables and only one significant and difficult to interpret interaction effect involving clinic (on hemoglobin A1c); thus, we con-

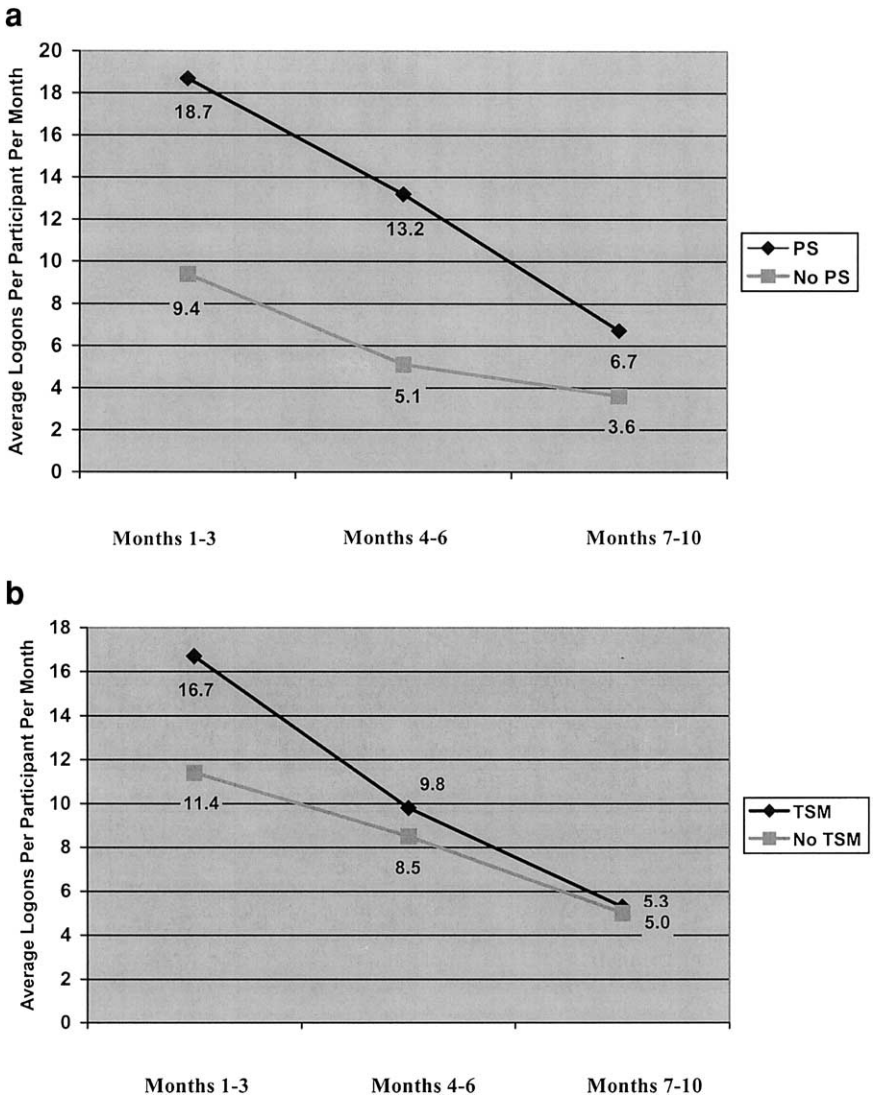

Fig. 1. (a) D-Net website usage. Peer Support (PS) vs no Peer Support (No PS). (b) D-Net website usage. Tailored Self-Management (TSM) vs no Tailored Self-Management (No TSM).

clude that the results were relatively uniform across intervention staff, major patient demographic variables, and clinics.

Discussion

The basic Internet-based self-management intervention in this study appears to be moderately successful. The intervention components received by all participants, which included Internet-based automated goal setting based on assessment results, identification of barriers and supports, updated diabetes information, and quarterly follow-up, produced results that were significantly improved from baseline on most outcomes and that appear to maintain for at least 10 months from baseline. Although in the absence of a usual care condition that did not receive the above components, we cannot rule out placebo effects or secular trends, we do not think it likely that the improvements observed were due to these factors. The magnitudes of dietary changes produced by this Internet-based intervention were as large as those found for the face-to-face treatment condition in our earlier randomized study with patients from the same population. These effects were much larger than the usual care control condition in the earlier study [47] and equal to or greater than those reported in other successful randomized trials evaluating moderate- or low-intensity interventions [48]. In addition, older adult patients generally increase their cholesterol levels over time in the absence of pharmacological intervention, rather than have 12–13 mg/dl reductions from baseline as in the present study. Thus, we conclude that this diabetes study is consistent with recent studies involving other patient populations that indicate that brief, computer-based interactive interventions can produce

Table 2
Overall change from baseline to 10-month follow-up

Measure	Baseline, M (sd)	10 months, M (sd)	*t* value (df)	Significance (*P* level)
Dietary behavior				
Kristal total — low is good	2.20 (0.46)	1.98 (0.50)	8.38 (236)	.000
Grams daily fat	42.49 (29.14)	28.85 (19.76)	9.59 (235)	.000
Other behavioral outcomes				
% guidelines met—includes smoking, if applicable	0.65 (0.20)	0.79 (0.16)	−11.16 (235)	.000
Average minutes per day 12 activity types	29.89 (23.05)	31.31 (24.40)	−0.83 (236)	.405
Psychosocial outcomes				
No. of barriers scored mod or great deal	4.85 (3.80)	2.92 (3.10)	8.96 (235)	.000
Diabetes total support scale	4.14 (1.26)	4.96 (1.26)	−9.31 (234)	.000
CES-D total score	17.93 (10.28)	13.32 (11.0)	−4.61 (235)	.000
Biological measures				
Total cholesterol	202.69 (40.53)	190.95 (38.10)	4.92 (243)	.000
Low-density cholesterol	115.99 (33.41)	107.71 (30.42)	3.87 (208)	.000
High-density cholesterol	39.57 (10.62)	39.98 (11.28)	−0.93 (241)	.354
Triglycerides	204.96 (84.34)	188.46 (82.35)	3.40 (208)	.001
Lipid ratio	5.43 (1.69)	5.08 (1.58)	4.22 (241)	.000
HbAlc hemoglobin	7.44 (1.62)	7.55 (1.47)	−1.26 (243)	.210

significant and relatively long-term improvements in dietary behaviors [48–51].

It was disappointing that the randomized intervention components of TSM or PS did not produce more incremental improvements, despite consistent delivery of these intervention components and repeated prompts. It may be that, within the context of low- to moderate-intensity interventions that can attract and involve a sizable percentage of the population of type 2 patients, it is difficult to improve upon the basic treatment package outlined above, which contains several recommended diabetes self-management strategies [52–54]. It should be noted that, although generally nonsignificant, there were patterns favoring either or both the TSM or the PS conditions on the Kristal FFB dietary fat measure (e.g., 12% vs 8.5% reduction from baseline) and on hemoglobin A1c (0.1 decrease vs 0.3 increase from baseline) and that the PS conditions did significantly enhance perceived support on the Diabetes Support scale. Thus, before giving up on ways to enhance long-term treatment effects, different modalities, frequencies, and refinements of potential maintenance enhancing components should be evaluated [1,55].

Due to logistical concerns, technical support constraints, and methodological issues, participants in the study did not have printers to produce hardcopies of information and were not able to link to other websites. Both of these factors may have limited the impact of the interventions. Also, selecting a group of novice Internet users may have limited the effectiveness of the intervention. Because of the inexperience of the participants, we were limited from using some more complex, interactive alternatives. Finally, in the PS conditions, due to the relatively limited sample size involved per condition, and in distinct contrast to nationwide chat rooms such as those on AOL and other widely used websites, there was also only limited activity on peer messaging aspects of the site at any given time, which may also have limited intervention effectiveness.

One purpose of the present study was to assess participants' use of the website over time. At this point it is not clear how long or how actively participants should use Internet-based intervention components to achieve meaningful changes in dietary behavior, physiological measures, or psychosocial outcomes. It is possible, however, that participants' involvement was insufficiently intense or consistent to result in substantial changes on the outcome measures that were selected. Results showed that there was an overall decrease in logins for participants in all conditions over the intervention period. Other recent Internet studies suggest that this finding is not unique to our study and may be a common feature of Internet-based interventions [56,57]. Furthermore, participants varied widely in how actively they used the website intervention components available to them. These findings suggest that it is challenging to develop websites that result in sustained use by participants when the intervention extends over many months. Programs developing such websites might make use of marketing research strategies that assess consumer needs and preferences [58].

This study was successful in addressing dimensions of the RE-AIM framework not reported before, to our knowledge, on Internet-based chronic disease self-management interventions (Table 4). We have previously documented that both the Reach (62% participation among relatively novice Internet users) and the Adoption (100% of clinics and 89% of providers approached participated) of the D-Net program were high [21,22]. Our present results indicate that these interventions can be implemented consistently by staff from different backgrounds and with a variety of patients from a variety of different primary care practices. Long-

Table 3
Means (SD) at baseline and 10 months (adjusted) and significance of difference

	Baseline, Mean (SD)	10-month adjusted mean[a] (SD)	Group differences (no intervention–intervention)	MANCOVA/ univariate *P* level
Dietary outcomes[a]				Mancova[d] = ns
Kristal total (low is good)				
No Peer Support	2.22 (0.41)	2.00 (0.38)	0.04	0.399
Peer Support	2.19 (0.50)	1.96 (0.38)		
No Tailored Self-Management Intervention	2.22 (0.45)	2.03 (0.38)	0.10*	.048
Tailored Self-Management Intervention	2.19 (0.46)	1.93 (0.38)		
Estimated g of daily fat				
No Peer Support	41.3 (26.4)	29.8 (14.3)	1.85	.323
Peer Support	44.0 (31.9)	27.9 (14.3)		
No Tailored Self-Management Intervention	44.4 (33.8)	29.8 (14.3)	1.98	.292
Tailored Self-Management Intervention	40.8 (23.8)	27.9 (14.3)		
Physical activity and guidelines[b]				Mancova[d] = ns
Average minutes activity per day				
No Peer Support	30.7 (24.1)	32.5 (22.8)	1.96	.512
Peer Support	29.4 (22.3)	30.5 (22.8)		
No Tailored Self-Management Intervention	26.8 (20.4)	32.1 (22.9)	1.25	.680
Tailored Self-Management Intervention	33.4 (25.4)	30.9 (23.0)		
Guidelines met (%)				
No Peer Support	65.19 (19.51)	78.94 (14.71)	−0.49	.798
Peer Support	64.82 (20.98)	79.43 (14.71)		
No Tailored Self-Management Intervention	66.68 (20.66)	79.97 (14.81)	1.57	.421
Tailored Self-Management Intervention	63.32 (19.69)	78.40 (14.81)		
Biologic outcomes[c]				Mancova[d] = ns
Alc hemoglobin (%)				
No Peer Support	7.35 (1.56)	7.68 (1.10)	0.28*	.051
Peer Support	7.54 (1.68)	7.42 (1.10)		
No Tailored Self-Management Intervention	7.43 (1.71)	7.67 (1.10)	0.26	.074
Tailored Self-Management Intervention	7.45 (1.53)	7.42 (1.10)		
Lipid ratio[e] (low is good)				
No Peer Support	5.44 (1.79)	5.13 (1.16)	0.11	.478
Peer Support	5.43 (1.59)	5.02 (1.16)		
No Tailored Self-Management Intervention	5.18 (1.44)	5.02 (1.17)	−0.10	.496
Tailored Self-Management Intervention	5.70 (1.89)	5.13 (1.16)		
Psychosocial outcomes[f]			Mancova[a] = $\lambda = 6.32$, $P < 0.000$	
CES-D total				
No Peer Support	17.8 (10.08)	14.06 (9.12)	1.47	.219
Peer Support	18.1 (10.51)	12.59 (9.13)		
No Tailored Self-Management Intervention	17.9 (10.56)	12.93 (9.11)	−0.79	.507
Tailored Self-Management Intervention	18.0 (10.02)	13.72 (9.12)		
Total Support Scale				
No Peer Support	4.23 (1.23)	4.71 (1.12)	−0.51*	.001
Peer Support	4.05 (1.28)	5.22 (1.11)		
No Tailored Self-Management Intervention	4.14 (1.32)	4.96 (1.12)	−0.01	.934
Tailored Self-Management Intervention	4.14 (1.20)	4.97 (1.12)		

[a] Adjusted for baseline covariate values of Kristal and estimated g daily fat.
[b] Adjusted for baseline covariate values of average minutes per day of activity and % guidelines met.
[c] Adjusted for baseline covariate values of HbAlc and lipid ratio.
[d] Wilks' λ.
[e] Ratio of total to HDL cholesterol.
[f] Adjusted for baseline covariate values of CES-D total and total support scale.
* The mean difference is significant at the 0.05 level.

term results, at the individual level, appear to be reasonably good, at least out to the 10 months following initiation. Thus, we conclude that although improvements were only modest on some outcomes, the basic intervention appears to be applicable across a variety of primary care referral sites, patients, and interventionists.

This study has both methodological strengths and limitations. Strengths include the randomized design, the reasonably large primary care sample, high participation rates among both patients and medical offices, on-line data collection and tracking of website usage, analyses to evaluate the impact of potential moderating or confounding vari-

Table 4
Main findings

1. The interventions were consistently implemented and on-line assessment procedures worked well.
2. Website usage was greatest among Peer Support participants but declined over time in all conditions.
3. There were few significant incremental effects of Tailored Self-Management or Peer Support.
4. Overall improvements across conditions at the 10-month assessment were encouraging on behavioral, psychosocial, and biological outcomes.
5. Results were robust and generalized across patient characteristics, on-line interventionists, and participating clinics.

ables, use of the RE-AIM evaluation framework, and a reasonably comprehensive set of outcome measures. Limitations include the absence of a significant proportion of minority participants, only limited involvement of the patient's primary care team [5,59], moderately high attrition (although not differential) rates, and the absence of a true no-treatment or usual care comparison condition.

Future research is needed to replicate and extend these results. In particular, we recommend investigation of other interactive modalities such as interactive voice response technology [60] that could be used to supplement and enhance Internet interventions; programs that create stronger linkages to primary care; and studies with different ethnic/racial groups and more diverse populations [61].

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