The Diabetes Network Internet-Based Physical Activity Intervention

A randomized pilot study

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OBJECTIVE — Because of other competing priorities, physical activity (PA) is seldom addressed in a consistent way in either primary care or diabetes education . This 8-week pilot study evaluated the short-term benefits of an Internet-based supplement to usual care that focused on providing support for sedentary patients with type 2 diabetes to increase their PA levels.

RESEARCH DESIGN AND METHODS — A total of 78 type 2 diabetic patients (53% female, average age 52.3 years) were randomized to the Diabetes Network (D-Net) Active Lives PA Intervention or an Internet information-only condition. The intervention condition received goal-setting and personalized feedback, identified and developed strategies to overcome barriers, received and could post messages to an on-line "personal coach," and were invited to participate in peer group support areas. Key outcomes included minutes of PA per week and depressive symptomatology.

RESULTS — There was an overall moderate improvement in PA levels within both intervention and control conditions, but there was no significant improvement in regard to condition effects. There was substantial variability in both site use and outcomes within the intervention and control conditions. Internal analyses revealed that among intervention participants, those who used the site more regularly derived significantly greater benefits, whereas those in the control condition derived no similar benefits with increased program use.

CONCLUSIONS — Internet-based self-management interventions for PA and other regimen areas have great potential to enhance the care of diabetes and other chronic conditions. We conclude that greater attention should be focused on methods to sustain involvement with Internet-based intervention health promotion programs over time.

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Patients with diabetes have an increased risk for coronary heart disease with substantial medical costs incurred for cardiac-related procedures and medications (1). Modification of coronary risk factors seem clearly indicated, and it is estimated that regular physical activity (PA) may reduce the risk of coronary heart disease for people with diabetes by 35–55% (2). Whereas PA may be contraindicated for some patients, the new national guidelines for moderate-intensity PA (i.e., 30 min of moderate-intensity PA ≥5 days/week) can be recommended for most patients, particularly those with type 2 diabetes (3,4).

In the context of primary care for diabetes, behavioral risk factors (such as PA, diet, and smoking) are not systematically addressed (5). The Internet-based Diabetes Network (D-Net) Active Lives program was initiated to address several major limitations of the most current approaches to diabetes education and behavioral self-management interventions, including the cost and time required of both patients and professionals and the limited reach and availability of programs for those who work, live in rural areas, are homebound, or do not want or cannot afford participation in group education sessions (2,6–8). Each of these limitations can be addressed by a diabetes-specific Internet-based web site (9).

There are currently 117 million U.S. households with access to the Internet, with some estimates as high as 167 million users (10,11). Improvements in Internet technologies, paired with the dramatic drop in the cost of getting on-line, and recent gains in access among the Digital Divide technology "have-not's" have created the potential to unite health care providers with patients in an unprecedented manner (10). Many web sites are now dedicated to helping consumers find health care information and support for a wide variety of chronic illnesses. These on-line health care consumers are active participants in on-line communities that provide information, patient-to-patient and professional-to-patient support, and self-help strategies (12,13).

The optimism for the potential positive impact of the Internet on diabetes self-management and education is attributable to several advantages of the Internet over traditional patient education, which act to reduce barriers and increase access to diabetes care. The Internet is available on demand, 24 h a day, at all times when patients are in most need of and prepared to utilize self-management information and intervention. Internet support conferences and chat rooms provide the opportunity for long-term ongoing support among patients and between patients and providers. In addition, the Internet can be used as an efficient system

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Abbreviations: ACSM, American College of Sports Medicine; ANOVA, analysis of variance; BRFSS, Behavioral Risk Factor Surveillance System; CDC, Centers for Disease Control and Prevention; D-Net, Diabetes Network; PA, physical activity; PAR-Q, Physical Activity Readiness Questionnaire.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

to monitor patient status, collect data, and provide tailored feedback and self-management counseling (14,15).

In the last several years, there has been a surge in the number of quality diabetes-specific web sites. However, despite the growing number of diabetes-related web sites and the potential advantages of using the Internet for diabetes education, support, and intervention, there is little empirical evidence that these web sites improve either the health or quality of life among those who use them (15,16).

The purpose of this study is to report the findings of a controlled randomized pilot study of the D-Net Active Lives program, an Internet-based PA program for those with type 2 diabetes. The study was designed to take advantage of the strengths of the Internet as a health care delivery platform to support the usual care provided to those with diabetes. We report on behavioral, mental health, program usage, and participant satisfaction outcomes.

RESEARCH DESIGN AND METHODS

— A sample of sedentary men and women with type 2 diabetes was recruited by e-mail postings to diabetes-specific UseNet groups, listserves, web sites, and on-line community groups that invited them to participate in a free 8-week Internet-based PA program.

Respondents were screened via an on-line questionnaire for participation criteria and, if eligible, informed consent was obtained. Inclusion criteria were a diagnosis of type 2 diabetes, age ≥40 years, and PA level below the current minimum recommendation by the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention (CDC) (i.e., 30 min of cumulative moderate-intensity activity ≥5 days/week) (2,4). Contraindications to moderate PA were assessed by the Physical Activity Readiness Questionnaire (PAR-Q) (17). Participants deemed ineligible or those who did not wish to participate were referred to an American Diabetes Association–recommended diabetes web site.

Participants next completed on-line registration forms and assessment questionnaires and were automatically randomized to either an Internet information–only condition or the D-Net Active Lives intervention condition; they accessed the site via a confidential user name and password.

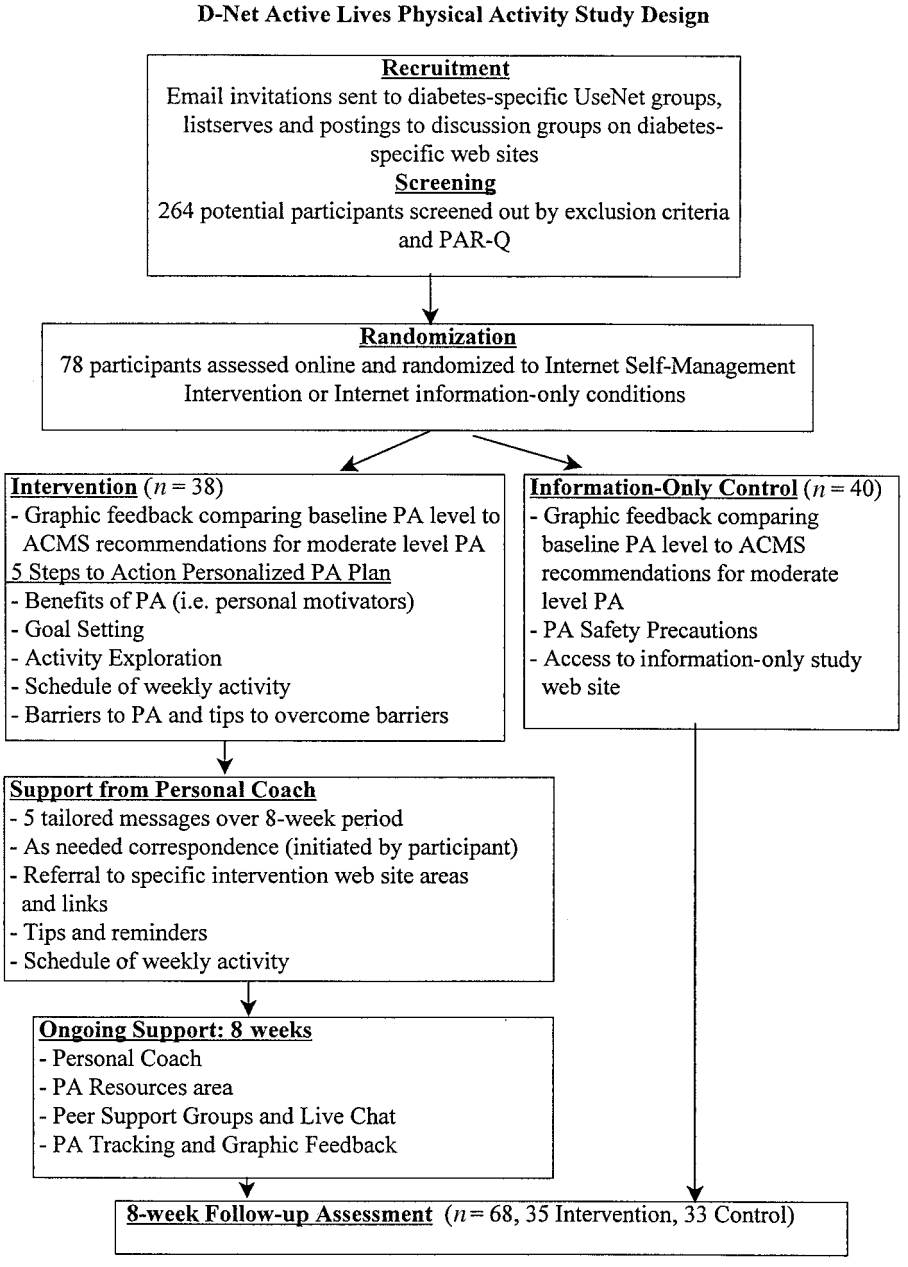

Figure 1—*D-Net active lives flow chart.*

During the 6-week recruitment period, 342 people attempted to register for the Active Lives program. However, because of stringent participation criteria, a total of 78 participants were randomized into the study. Among those who declined or were disqualified from participating, 29% failed one or more qualifiers for inclusion (e.g., had type 1 diabetes rather than type 2 diabetes), 28% declined after reading the general program description, 23% engaged in PA that met or exceeded current ACSM/CDC national recommendations for PA, 4% were disqualified for medical reasons (PAR-Q), 1% were disqualified on at least one informed consent question, 5% failed to complete the baseline assessment, and 5% did not register (i.e., they did not provide personal information, e-mail address, phone number, etc.) for the study.

Participants were geographically diverse, representing 31 states and provinces within the U.S. and Canada. All participants were English speaking. The intervention and control conditions did not differ significantly on any baseline measures. Overall, the mean age was 52.3

years; 53% were female, 82% were Caucasian, 50% completed college, 62% were employed full-time, 22% were taking insulin, 83% were diagnosed with diabetes for >1 year, and 75% had one or more comorbid chronic disease. Because there was a trend toward significance ($P < 0.10$) across sex-specific conditions, sex was included as a factor in the subsequent outcome analyses.

Design and procedures

A total of 78 participants with type 2 diabetes were randomly assigned by the system to an Internet information–only comparison condition ($n = 40$) or the Internet Active Lives Intervention ($n = 38$). Assessments of PA frequency and duration and depressive symptomatology were conducted on-line at baseline and at 8-week follow-up (Fig. 1).

Information-only condition. Participants assigned to the information-only condition were able to access diabetes-specific articles in the web site's library as well as real-time blood glucose tracking with graphic feedback for the 8-week duration of the study.

Active Lives Intervention. Participants assigned to the intervention received an 8-week personalized PA program tailored to their individual needs. The intervention was based on a multilevel social-ecological model of diabetes self-management and follow-up support for behavior change (5). Participants were assessed on-line for PA level and received specific feedback on their baseline activity level in relation to national guidelines for regular moderate-level PA. Participants were then led through a "5 Steps to Action" planning process, in which they first identified the benefits of PA (i.e., personal motivators) and next selected a PA goal to gradually increase the number of days per week and minutes per day that they would engage in moderate-intensity PA. Subsequent steps included selecting two preferred physical activities from an "activity exploration" checklist, scheduling days of the week and times of day that they would do these activities, and identifying two personal barriers to PA from a barriers checklist. Both individual barriers selected and associated tips for overcoming their personal barriers were always available on the web site for review and print out. Participants were encouraged to log onto the web site at least once a week to review their PA plan and to use the web site's PA resources, personal coach, and peer-to-peer support areas.

Personal PA database. Participants in the intervention group also had access to a private personal database, from which they could enter and track their total minutes of PA per day as well as generate graphs of their progress. In addition, a resource area with a collection of PA-specific how-to articles, tips, and motivational stories was provided.

Personal coach counseling and support. After the baseline assessments and "5 Steps to Action" planning process, participants in the intervention group had access to an on-line support area. When a participant initially entered the support area, they received a tailored welcome message from their personal coach, which commented on their specific action plan and goals and encouraged their participation by asking them to respond by posting a reply message. Over the 8-week period, each participant received four additional tailored messages from the coach on PA topics tailored from information provided by their baseline assessment, a message to review and revise their goals after the first month, suggestions on how to revitalize their program, and a final message suggesting strategies to maintain newly acquired PA habits. In addition, participants were encouraged to initiate ongoing contact with the coach by posting specific questions, problems, and accomplishments to their private personal coach conference area. All of these messages were responded to by the personal coach within 48 h.

The personal coach (an occupational therapist) had access to an endocrinologist, a registered dietitian, and an exercise physiologist to help answer questions and to assure that all advice provided was safe and appropriate, however, these resources were seldom needed because most of the on-line interactions with the coach focused on behavioral issues in initiating and maintaining a PA program.

Other ongoing support. In addition to personal coach support, participants in the intervention group also had the ability to communicate to other members in the intervention group via the "Active Lives Support Group" conference area. This area allowed group members the opportunity to share information and provide emotional encouragement and support for engaging in their PA program by posting messages. A separate peer-interaction area was also available for focus topics, where specific PA-related topics (e.g., "PA Barrier Busters") of potential interest were posted by research staff, and participants were encouraged to post comments and share their thoughts on the topic(s).

Measures

All measures were administered on-line at baseline and at the 8-week follow-up and included automated error trapping to ensure complete data and eliminate out-of-range value responses. At follow-up, phone calls were made to collect data if participants had not completed the on-line assessment after 10 days.

Outcome measures

PA. A total of 11 items related to work and nonwork PAs from the Behavioral Risk Factor Surveillance System (BRFSS) (18) were used. These questions elicit information on moderate- and vigorous-level activities, walking, strengthening, and sedentary activities. These items constitute a new PA item set designed to assess whether respondents meet the new CDC PA recommendations.

Six items were taken from the BRFSS questions related to nonwork PA (18). The questions elicited information on weekly minutes of vigorous and moderate-level activities (including brisk walking) as well as a separate question about weekly minutes of any intensity of walking. A total PA score for each individual was calculated by combining the total weekly minutes of vigorous and moderate activity performed. Similarly, total weekly minutes of walking were calculated by multiplying the number of minutes walked per day by the number of days walked per week.

Depression. A measure of depression was included because of evidence suggesting that Internet use is associated with increased levels of depression (19) and that regular PA is associated with lower levels of depression (20). A 10-item version of the Center for Epidemiologic Studies Depression scale was used to assess current depressive symptomatology (21). The 10 items were selected from the original 20-item version based on high factor loadings on Radloff's four factors (two Depressed Affect, four Positive Affect, three Somatic, one Interpersonal, Cronbach's $\alpha = 0.82$, test-retest $r = 0.67$, $P < 0.001$). The 10-item scale was prorated to reflect the 20-item scale scores

Table 1—*Outcome results by treatment condition*

Measure/condition	Baseline	Follow-up	Time *F* (1,64)	Group × Time *F* (1,64)	Group × Time η^2
Physical activity summary					
Moderate-to-vigorous exercise (min/day)			29.59 ($P < 0.001$)	0.01 ($P = 0.938$)	0.000
Unadjusted					
Intervention	5.6 ± 6.2	17.6 ± 15.3			
Control	7.3 ± 6.2	18.0 ± 17.3			
Log-transformed					
Intervention	0.60 ± 0.47	1.03 ± 0.57			
Control	0.75 ± 0.45	1.12 ± 0.42			
Walking (min/day)			15.62 ($P < 0.001$)	0.08 ($P = 0.781$)	0.001
Unadjusted					
Intervention	6.4 ± 6.2	12.5 ± 9.5			
Control	8.4 ± 8.4	16.8 ± 22.8			
Log-transformed					
Intervention	0.68 ± 0.45	0.96 ± 0.48			
Control	0.78 ± 0.46	1.01 ± 0.49			
Depressive symptoms (CES-D)					
Intervention	16.9 ± 11.6	14.9 ± 12.5	0.06 ($P = 0.809$)	2.77 ($P = 0.101$)	0.042
Control	17.6 ± 10.4	19.9 ± 14.2			

Data are means ± SD. CES-D, Center for Epidemiologic Depression Scale.

(0–15 = not depressed, 16–20 = mildly depressed, 21–30 = moderately depressed, 31–60 = severely depressed) (22).

Process measures

Measures used to track and evaluate program implementation and to understand how the intervention worked included automated measures of participation (use of various components of the program) and a user satisfaction survey. Web site usage variables were collected to describe the extent of use and the appeal of the system, and a user satisfaction survey was administered at the 8-week follow-up. The survey included quantitative measures of user satisfaction derived from the Client Satisfaction Questionnaire (23), with content, ease of use, and more qualitative open-ended questions about project-specific suggestions for program improvements.

RESULTS

Characteristics of postassessment survey–completers versus nonrespondents

Of the 78 participants, 68 (87%) completed the postassessment survey (33 of 40 [82.5%] control subjects and 35 of 38 [92.1%] intervention subjects). Compared with the prepost panel sample, the nonrespondents did not differ with respect to treatment condition, age, sex, ethnicity, educational level, employment status, years diagnosed with diabetes, diabetes medication, comorbidity, or any of the three preassessment outcome measures.

Outcome analyses

To evaluate intervention effectiveness, 2 × 2 × 2 (treatment condition by sex by time) repeated measures of analysis of variance (ANOVA) were conducted on the three outcome measures. Because the measures of moderate-to-vigorous intensity PA and walking were positively skewed, logarithmic transformations were performed on those measures before analysis. The means, SDs, and test statistics are presented in Table 1. Although significant time effects were obtained for moderate- to vigorous-intensity PA and walking, no significant condition × time effects were obtained for the three outcome measures. None of the condition × time × sex effects attained statistical significance.

Overall, participants reported a moderate increase in both walking and moderate-to-vigorous intensity PA. There was a nonsignificant pattern for intervention participants to show decreases in depressive symptomatology, whereas control participants showed increases ($P = 0.10$).

Program usage

Web site activity analysis revealed a total of 341 logons (means = 1.1 logons per participant per week) for the intervention condition and 105 (0.3 logons per participant per week) for the control condition participants over the 8 weeks of the study. Total web pages viewed for the intervention condition was 9,962 versus 1,811 page views for the control condition. Participants' average session duration was 13 min for the intervention condition and 11 min for the control condition. Participants in the intervention condition recorded 5,938 page views (156.3 per participant) within the behavior change–focused (e.g., tracking and scheduling PA, Action Plan review, etc.) Active Lives area and 310 page views (8.2 per participant) within the diabetes-specific information library area of the web site. The intervention group posted 80 messages (2.1 per participant) to their personal coach and 42 messages (1.1 per participant) to the peer support group areas.

There was a steep decline in usage of the program over the 8 weeks of the study. Intervention participants recorded 204 logons (2.7 per participant) during the first 2 weeks versus 40 logons (0.5 per participant) during the last 2 weeks of the study. A similar decline in participation was noted for the control condition, which initially recorded 77 logons (0.9

per participant) versus 7 logons (0.09 per participant) during the last 2 weeks of the study.

Participant outcomes

Because the number of total logons over the 8-week period of the study was highly related to the number of postings to the personal coach ($r = 0.71$, $P < 0.001$) and to the peer support group ($r = 0.91$, $P < 0.001$), only the total number of logons was used to evaluate the association between program use and the three outcome measures. A median split on total logons was used (i.e., three or more occasions versus less than three occasions) to compare participant outcomes by program usage. Participants who used the program on three or more occasions (intervention condition $n = 20$, control condition $n = 12$) were compared with those who used the program on less than three occasions (intervention condition $n = 15$, control condition $n = 21$) using $2 \times 2 \times 2$ (condition by program use by time) repeated measures of ANOVA. A significant condition $\times$ program use $\times$ time effect was obtained for change in moderate-to-vigorous intensity PA ($F[1,64] = 4.48$, $P = 0.038$, $\eta^2 = 0.065$) but not for walking or depressive symptomatology. To interpret the three-way interaction, subsequent 2×2 ANOVAs were conducted within condition. A significant program use $\times$ time effect was obtained only within the intervention condition ($F[1,33] = 4.19$, $P = 0.049$, $\eta^2 = 0.113$). Those in the intervention condition who used the program on three or more occasions reported greater change (means $\pm$ SD) in moderate-to-vigorous intensity PA (preassessment logarithmic 0.58 ± 0.51, postassessment logarithmic 1.20 ± 0.48) compared with those who used the program on less than three occasions (preassessment logarithmic 0.62 ± 0.44, postassessment logarithmic 0.80 ± 0.62).

Participant satisfaction

At the 8-week assessment, a significantly larger percentage of participants within the control condition, compared with those in the intervention condition, reported that they had not used the program on a frequent basis (59 vs. 34%, $\chi^2[1, n = 67] = 4.23$, $P = 0.040$). Among those who used the program, the intervention participants ($n = 23$) reported greater overall satisfaction on a six-point Likert-type scale (strongly agree to strongly disagree) compared with the control participants ($n = 13$, 4.9 ± 1.4 vs. 3.7 ± 1.7], Student's t value $= 2.07$, $P = 0.047$). Conditions did not differ significantly on satisfaction ratings of the program's relevance to participants needs (5.1 ± 1.2 vs. 4.1 ± 1.2, $t = 1.96$, $P = 0.058$), ease of use, or helpfulness of the PA section. Within the intervention condition, 88% reported finding the personal coach component helpful compared with only 35% who found the peer-to-peer support group helpful.

CONCLUSIONS — This small randomized trial produced important lessons about Internet-based self-management programs. Although there were no significant between-condition differences in outcomes, this mode of delivery appears effective for increasing activity levels among those patients who use the service with sufficient regularity.

The major drawback to the intervention was the steep decline in usage across weeks, and internal analyses revealed that there was a significant relation between extent of web site use and level of improvement in PA. This pattern of declining use over time does not appear to be unique to our study (24,25). Future research should explore ways to enhance ongoing use, including approaches such as contracting to use the site a minimum number of times per week and/or incentives for regular use.

Although the convenience and anonymity of Internet-based health care access are two of its greatest strengths (13,14), these factors may also encourage frequent "surfing" from site to site rather than consistent use of any one support site. Rather than being a limitation to web-based interventions per se, this is likely a general feature of intervention research and one of the reasons why many drug trials use stringent participant selection procedures or run-in periods (26). The findings regarding depressive symptomatology were instructive and generally encouraging. Intervention participants reported improvements in depressive symptoms, which is in contrast to reports of Internet use being associated with increased symptoms of depression (19).

Lessons learned

Strengths. Strengths of this study include exploration of the issues discussed above, which to our knowledge have not been reported previously in the diabetes literature. Other strengths include the successful implementation of on-line data entry, the immediate scoring and feedback to participants on questionnaire results to tailor the intervention, the randomized design, and the analysis of the log file web site–usage data.

For self-management behaviors, such as PA or smoking cessation, which are infrequently addressed in primary care for diabetic patients (7,27), an Internet-based system could be a useful complement to care if integrated with other aspects of care and if accompanied by advice from the primary care provider, incentives for regular use, and prompts (28). Finally, intervention participants were provided with a clearly structured method for developing a personalized PA plan. Through the "5 Steps to Action" section, participants were provided a step-by-step method for setting a reasonable PA goal, identifying specific activities they could do on a regular basis, scheduling those activities, and anticipating barriers that could interfere with their goal.

Limitations. Limitations of this research include the small sample size, the short follow-up period, and the absence of biological outcome measures, which would have been logistically challenging because participants were highly dispersed geographically. One of the study's key strengths (i.e., using on-line recruitment, assessment, and support modalities) also presented some key limitations. Although these methods were efficient from a labor-intensive, cost, and speed of response perspective, the hit-or-miss nature of Internet recruitment necessitated that a large net be cast to obtain the desired sample size. General e-mail solicitation (e.g., to members of diabetes UseNet groups, listserves, and web site conference areas) yielded far fewer responses than anticipated and does not provide a way to determine the number or characteristics of potential participants who saw the posting and chose not to respond. These data are based on self-report measures, so it is possible that some individuals overestimated their daily minutes of activity.

The use of the peer support area was disappointing and provides an important lesson for health care web sites. It appears that a sizable number of participants (and considerable time) is needed to have a sufficient critical mass of participants to gen-

erate active and vibrant on-line support groups. Participants also needed to take the initiative to read posted messages from their personal coach to receive the complete intervention. Individual initiative also affected the quality of the support offered because tailoring of advice and counsel is only as good as the information available for tailoring. As a result, those individuals who were active and willing to disclose information on an ongoing basis received extremely tailored coaching that was appropriate to their situation and increased their activity levels. Those who never posted, or who posted sporadically, received one-way messages from the coach that may or may not have been very useful.

Finally, research on Internet-based health care behavioral interventions is in its infancy. The demographic characteristics of this study limits its generalizability because it does not include participation among those with less education or minority groups disproportionately affected by type 2 diabetes. However, the rapid change in the demographics of Internet use toward being more reflective of the general population, including underserved and minority groups (10), suggests that the Internet may be a viable adjunct to diabetes self-management programs in the future.

Implications for future research

Future research should explore the reach and representativeness of patients willing to use Internet resources, which initial research suggests may be very high (29). In addition, we need to develop ways to enhance regular usage of key intervention components and to maintain web site use over time while yielding larger samples and longer-term follow-up. It may be instructive for future research in this area to develop barriers-to-use of Internet-based programs with the hope of making these programs more appealing to participants. If methods can be found to stimulate ongoing involvement with Internet-based interventions, such programs may prove to be useful adjuncts to help address the frequently neglected behavior-change issues associated with diabetes (27).

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