An online positive affect skills intervention reduces depression in adults with type 2 diabetes

Michael A. Cohn, PhD, Martha E. Pietrucha, BA, Laura R. Saslow, PhD, Jen R. Hult, MPH, and Judith T. Moskowitz, PhD

Abstract

Positive affect predicts improved glycemic control and longevity in adults with type 2 diabetes. We tested DAHLIA, a self-paced online intervention for type 2 diabetes that teaches positive affect skills such as savoring, gratitude, and acts of kindness. Participants (n=49) were randomized to the 5-week DAHLIA course or an emotion-reporting waitlist control. DAHLIA was understood and accepted by participants and showed good retention (78%). At post-intervention, DAHLIA participants showed a significantly greater decrease in depression than controls (−4.3 vs. +0.6 points on the CES-D, \( p = .05 \)). Secondary analyses found that this effect was considerably stronger in intervention recipients recruited online than those recruited in person. Intervention recipients recruited online also showed significantly increased positive affect, reduced negative affect, and reduced perceived stress. There were no effects on measures of diabetes-specific efficacy or sense of burden, or preliminary measures of health behaviors. This successful feasibility and efficacy trial provides support for a larger trial focusing more specifically on health behavior.

Author Contributions

JTM developed the original positive affect intervention and oversaw the design and execution of the study. MAC led adaptation of the intervention, implemented the study, and performed the analyses. JRH and MEP contributed to intervention adaptation, study logistics, and participant recruitment and contact. LRS contributed to intervention adaptation and study design. The manuscript was prepared by MAC and JTM and approved by all authors.

Conflicts of Interest

None
likelihood of tobacco use [9,10]. Research on individuals newly diagnosed with HIV indicates that positive affect prospectively predicts greater likelihood of engagement in care and better medication adherence [11]. A series of studies by Isen and colleagues provided a self-affirmation, coping, and positive emotion intervention to several different patient populations and found an overall relationship between positive affect change and health behavior change [12,13,14,15].

We have developed an intervention consisting of skills to increase positive emotion that shows promise for improving psychological well being in people experiencing significant life stress [16,17,18]. The potential benefits include not only the health correlates of positive affect described above, but also improved psychological well-being and coping with life stressors. The intervention is based on revised Stress and Coping Theory [19] and the Broaden-and-Build Theory of positive emotion [20]. These theories describe ways positive emotion supports coping and well-being, such as providing a psychological “time-out” from experiences of distress and helping individuals invest in intellectual and social resources that support future coping.

Positive Affect and Depression

Depression is common in people with type 2 diabetes [21] and is associated with poorer glycemic control, increased symptoms and complications, poorer adherence to exercise and diet recommendations [22], and elevated risk of mortality, over and above the elevations in risk associated with diabetes itself [23].

Interventions based on increasing positive affect and experiences have shown promise as a treatment for depression. A meta-analysis of 25 programs targeting constructs such as gratitude, happiness, and optimism found a medium effect size for relief of depression symptoms (median $r = .26$), with stronger effects for currently-depressed participants [24]. These positive psychology interventions show effectiveness and durability similar to that of psychotherapy or pharmacotherapy [24]. The focus on pleasurable and rewarding activities of positive psychology interventions resembles the approach of Behavioral Activation (BA) therapies, which have also shown substantial effectiveness at treating depression [25]. Psychological interventions that specifically target depression in samples of people with type 2 diabetes have shown some efficacy (e.g., [26]) but tend to be time intensive for both the patient and the provider, expensive to deliver, and difficult to disseminate in home or other non-clinic settings [27].

Online intervention delivery addresses many of these challenges. Interventions delivered online via computer or mobile format are comparatively inexpensive, easily delivered at multiple locations like clinics, libraries or other public computer terminals, patients’ homes, or even in transit using mobile devices; and are available at times convenient for patients which maximizes the likelihood that the intervention will be accessed. Furthermore, online formats can offer a flexible menu of content to meet individual patient needs and preferences, can include automatic reminders or boosters via email or text, and easily provide ongoing content and support at low cost.
Online interventions for diabetes self-management and depression are feasible and have shown some efficacy [28][29] at improving symptoms of depression and some health outcomes. In a meta-analysis, Pal and colleagues[30] found that online diabetes self-management interventions have a small, but statistically significant, effects on HbA1c, diet, and lipids, but do not consistently improve depression symptoms.

Several meta-analyses of internet and computerized interventions, both self-help and clinician-assisted[31,32,33,34], found that internet interventions can reduce symptoms of depression, including among those who might otherwise lack access to treatment. The most successful of these interventions have a variety of components and interactive elements to encourage engagement (including Beating the Blues, which is approved for use by the British National Institute for Health and Clinical Excellence [35,36,37,38,39,40].)

The DAHLIA Intervention

We have developed an intervention (DAHLIA: Developing Affective HeaLth to Improve Adherence) consisting of 8 skills that have been empirically demonstrated to enhance day-to-day positive emotion or adaptive coping. The skills are:

1. Noticing and recalling positive events [41,42] [43,44] [19]
2. Savoring or capitalizing on positive events [45] [46]
3. Gratitude [47,48,49]
4. Mindfulness [50,51,52,53]
5. Positive reappraisal [19,54]
6. Self-affirmation and recognizing personal strengths [55] [56,57][58]
7. Setting attainable goals[59,60,61,62,63]
8. Performing acts of kindness [64,65] [66] [67] [68]

Lesson content and exercises are described in Table 1. The full rationale and development methodology have been described previously [16,17]. Generally, the intervention is based on skills for improving coping or generating positive affect that have been validated in past research. Participants practice one or more of these skills each day. Mindfulness exercises are continued throughout the intervention because we believe they may also help participants recognize and appreciate positive events, even in the context of chronic stress.

The intervention targets improvements in depression rather than diabetes-specific cognitions and health behaviors. Participants are told that they can choose to apply the skills to coping with diabetes, or to other domains of life in which they would like to increase positive emotion or cope more effectively.

The Present Study

Because this was a very early study, we chose to focus on establishing efficacy relative to an emotion-reporting control group while gathering participant feedback and data on retention. Our primary hypothesis was that the DAHLIA intervention would lead to improvements in
important components of psychological well-being: Decreased stress, negative affect, and symptoms of depression, and increased positive affect.

We also explored the possibility that the intervention would lead to improvements in several diabetes-specific measures: diabetes-related self-efficacy, diabetes-related distress, physical exercise, medication adherence, and daily glucose testing. We considered these secondary hypotheses because the proximal targets of the intervention were the psychological outcomes.

Finally, we performed exploratory analyses comparing participants recruited in-person from a diabetes education class to a more heterogeneous group recruited online. We did not have a priori hypotheses about how they might differ.

Method

The study protocol was approved by the UCSF Committee on Human Research. All participants had an in-person or telephone conversation with a recruiter who explained the study and answered their questions, after which they read a written informed consent statement and gave consent to participate on the study website.

Participants

Participants were 53 adults with type 2 diabetes. They were recruited either in person through diabetes education classes at the University of California, San Francisco Diabetes Education Center (n = 28) or online through advertisements in the “volunteers” section of the San Francisco Bay Area Craigslist (n = 25). The online ad described the study as “testing whether learning skills for creating positive emotions and enjoying life might make people better at dealing with diabetes-related stress and taking care of their health” and described the compensation for completing study assessments (see “Procedure,” below). Participants recruited in person received a similar description from a study staff member.

Materials

On the first 1–2 days of each week, participants read a brief lesson introducing that week’s skill(s). For the rest of the week, they received a “home practice” assignment consisting of one or more simple practices, such as noticing positive events or tracking progress toward an attainable goal. Participants were asked to visit the website every day to record their home practice and complete the daily emotion reporting questionnaire.

New lessons became available 7 days after beginning the previous lesson, provided that the participant completed the home practice at least once. Participants were also allowed to postpone beginning a new lesson if they did not have time to read the material on the day it became available.

Procedure

After completing an online informed consent, participants completed the baseline questionnaire battery. They then began filling out daily emotion reports. Those who completed four emotion reports within the first 7 days were randomized to begin the
intervention or to the control condition in which participants continued for 60 days of emotion reporting only\(^1\). Throughout the study, participants in both groups received an automated daily email with a link to the website. The email included a link that could be used to opt out of future reminders, but no participant chose to do so.

The post-intervention questionnaire battery was administered a week after the final lesson for intervention participants. This was an average of 57 days after the baseline measures for intervention participants (due to participants who opted to spend more than one week on some of the lessons) and an average of 63 days after baseline for control participants\(^2\). Finally, all participants received a follow-up phone call from an interviewer to collect feedback about their experience in the study approximately 7 days after the post-intervention questionnaires. Control participants were then given access to the intervention website.

Participants were paid $1 for each daily report completed, $20 for completing the final questionnaires and phone interview, and $20 if they completed the study within 75 days with reports on 75% of all days. The maximum total a participant could receive was $100. Intervention participants were informed that the compensation was for completing the daily questionnaires, and that they could continue visiting the site and earning payment for completing assessments even if they chose not to continue with the intervention. None of the participants did this (all either chose to continue with the intervention or dropped out of the study).

**Measures**

**Primary outcome measures**—*Depressive Symptoms* were measured using the CES-D\(^69\), a measure of clinical and subclinical depressive symptomatology. On a 4-point scale, participants indicated how often they had felt symptoms in the past week (0 = “*Rarely or none of the time – less than 1 day*”; 4 = “*All of the time – 5–7 days*”), such as “I felt that I could not shake off the blues even with help from my family or friends.”

*Perceived Stress* was measured with the Perceived Stress Scale (PSS; [70,71]). The PSS is a widely-used measure of psychological stress designed for community samples. We used the 10 item version of the scale in which participants respond how often (1 = “*never*” to 5 = “*very often*”) during the past month they experienced thoughts and feelings such as “felt that you were unable to control the important things in your life” and “been unable to control irritations in your life.”

*Positive and Negative Affect* were measured with the Differential Emotions Scale (DES; [72]). Participants are asked to rate on a nine-point scale how often they experienced each of 23 positive and negative emotions, such as “*grateful*” or “*anxious or scared*” (0 = “*Not at all*”; 8 = “*All the time*”). Positive and negative emotion scores were calculated based on two different versions of the DES, one given at baseline and post-intervention that asked about

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\(^1\)We used fully random assignment based on a computerized random number generator. This led to a chance discrepancy in cell sizes: 29 participants were assigned to the intervention and 20 to the control condition.

\(^2\)The length of the emotion reporting period was based on our estimate of how long it would take intervention participants to complete the lessons. Average time to complete the intervention was lower than expected, leading to the slight mismatch between groups in time spent in the study.
the last two weeks, and one given every day of the study that asked about the past 24 hours. For the daily measure, the baseline score was an average of the reports from the run-in emotion reporting period and the post-intervention score was an average of the last four days of the study.

**Diabetes-specific psychological measures—**Diabetes self efficacy was measured using a version of the Confidence in Diabetes Self-Care scale (CIDS;[73]) adapted for type 2 diabetes. Participants used a 5-point scale to rate their confidence that they could perform 23 self-care activities, such as “check your feet for sores or blisters every day” and “ask your doctor questions about your treatment plans.”

Diabetes-related distress was measured using the Diabetes Distress Scale (DDS; [74]). Participants read 16 potential diabetes-related difficulties and use a 5-point scale to rate how much of a problem each one had been over the past month.

**Health Behaviors:** Each day participants were asked three health behavior questions about the previous day: Whether they had tested their blood sugar (not at all, once, or more than once), whether they had taken their medication as directed (none, some, or all), and how much walking or exercise they had done (<10 minutes, 10–30 minutes, or >30 minutes). The measure was scored 1 for days on which the participant was “fully adherent” (tested glucose at least twice, took all medication, or >30 minutes of activity) and 0 otherwise. Daily scores were then averaged to create a pre-intervention score (based on the emotion-reporting run-in period) and a post-intervention score (based on the last 4 days of the study) for each measure. Thus, scores of 0 represent nonadherence or imperfect adherence on all days during the period, and scores of 1 represent perfect adherence on all days.

**Analytic Plan**

For each dependent variable (depression, perceived stress, positive and negative affect, diabetes self-efficacy, diabetes distress, and diabetes-relevant health behaviors) change over time was assessed using a regression model with Time 2 as the dependent variable and Time 1 and treatment condition as simultaneous predictors. In follow-up analyses, we then expanded the model to include recruitment type (online recruitment vs. in person), with participants recruited online as the reference group, and the interaction between recruitment type and condition.

**Results**

The overall sample was 50.9% female and had a median age of 54 years. The sample was 36% Caucasian, 23% African-American, 19% Asian or Asian-American, 8% non-White Hispanic; 15% identified as other races or declined to respond. Intervention and control groups did not differ on age ($F = 2.59, p = .11$), gender ($\chi^2 = .66, p = .42$), or any racial category ($\chi^2 < .163, p > .20$). At baseline the groups did not differ on any outcome measures ($F < 2.55, p > .12$).
**Completion Rates**

Of the 53 participants recruited, 49 (92%) completed the initial emotion reporting run-in and were randomized (see Figure 1 for the CONSORT flow diagram). Forty-two participants (25 intervention and 17 control; 79% of the original sample) completed the final questionnaires. This is the sample used in the analyses reported below.

Control participants were considered “full completers” if they submitted at least half of the daily emotion reports (30 of 60). Intervention participants were considered full completers if they reached the fifth and final lesson. Thirty-eight participants (72% of the original sample) met this criterion.

**Website Use**

Participants visited the study website an average of 5.0 times per week. Control participants visited significantly more frequently than intervention participants (5.8 vs. 4.5 visits / week; \( F = 4.28, p = .05, \eta^2 = .10 \)), possibly due to the greater time commitment required for intervention visits (reading lessons or doing exercises in addition to completing the emotions questionnaire).

**Primary Outcomes: Depression, Affect, and Perceived Stress**

Results are summarized in Table 2.

**Depression**—Depression scores dropped significantly in the intervention condition compared to control (\( \beta = -.21, p = .05 \)). Scores in the intervention condition dropped by 4.3 points, from a mean of 16.9 – above the threshold for probable clinical depression – to 12.6, well below the threshold. Exploratory analysis found that this effect did not appear for the subset of positive affect CES-D items (\( \beta = .05, p = .71 \)), but only the negative items (\( \beta = -.25, p = .03 \)).

**Perceived Stress**—The intervention did not have a significant effect on PSS scores (\( \beta = -.13, p = .31 \)).

**Positive and Negative Affect**—The retrospective and averaged daily measures were strongly correlated with each other for both PA and NA and at both timepoints (\( r \)s ranging from .61 to .85, \( p < .001 \)). There was no significant effect of condition for positive or negative affect, using either measure (\( |\beta| < .15, p > .20 \)).

**Diabetes-Specific Psychological Measures**

Neither the diabetes self-efficacy scale nor the diabetes distress scale showed any intervention effect (\( |\beta| < .09, p > .20 \)).

**Health Behaviors**

There were no significant effects of the intervention on any health behavior measure (\( |\beta| < .19, p > .20 \)).
Most participants had perfect medication adherence on all days (19/24 or 76% at T1 and 21/24 or 84% at T2), suggesting that medication adherence is not a large concern in this population, or that problems with adherence that do exist are not picked up by self-report. Glucose testing was highly dichotomized, with nearly all participants scoring either 0 (never tested twice or more in a day) or 1 (tested twice or more every day; 88% scored 0 or 1 at baseline and 80% at post-intervention). There was almost no change between timepoints. We tested an alternate scoring method in which days with 1 glucose test were scored as 0.5 instead of 0, which produced more variance among the participants with imperfect adherence but did not change the results.

### Exploratory Analyses

**Online vs. Offline Recruitment**—Recruitment method did not predict likelihood of reaching randomization ($\chi^2 = .85, p = .36$). However, participants recruited online were significantly more likely to complete the final measures (92% vs. 68%, $\chi^2 = 4.68, p = .03$) and to be full completers (88% vs. 57%, $\chi^2 = 6.20, p = .01$). Condition assignment was not related to either completing the final measures or reaching the full completer criterion ($\chi^2 < .13, p > .72$).

**Website Use:** Frequency of visits was not affected by recruitment method and there was no interaction between recruitment method and condition. ($F < .78, p > .38$).

For the key psychological outcomes, the effects of adding recruitment type to the analyses are summarized in Table 3.

**Depression and Recruitment Type:** When recruitment type was added to the model, the effect of condition became stronger ($\beta = -.34, p = .02$). The interaction was not significant ($\beta = .25, p = .21$), though the intervention appears to have had a considerably stronger effect for participants recruited online (see Figure 2): a reduction of 7.2 points, from above to below the criterion for probable clinical depression; versus a 1.4 point reduction for those recruited offline.

**Perceived Stress and Recruitment Type:** When recruitment type was added, significant effects emerged ($\beta_{\text{cond}} = -.43, p = .01; \beta_{\text{offline}} = -.36, p = .08; \beta_{\text{interaction}} = .62, p = .01$). Scores dropped significantly for participants in the intervention who were recruited online, but not those recruited offline (see Figure 2).

**Positive Affect and Recruitment Type:** When recruitment type was added, a significant effect of condition emerged for retrospective PA ($\beta_{\text{cond}} = .32, p = .05$); a marginal interaction indicated that the intervention increased PA only for intervention participants recruited online ($\beta_{\text{interaction}} = -.35, p = .10$). There were no significant effects for the averaged daily PA measure (see Figure 3).

Negative affect and recruitment type: For NA, the retrospective measure had a similar pattern of marginal effects ($\beta_{\text{cond}} = -.35, p = .08; \beta_{\text{interaction}} = .46, p = .10$), indicating that the intervention reduced NA for participants recruited online but not offline. The averaged
daily measure showed the same pattern, though the interaction fell short of significance ($\beta_{\text{cond}} = -0.32, p = 0.09; \beta_{\text{interaction}} = 0.38, p = 0.13$; see Figure 3).

**Diabetes Specific Measures:** Adding recruitment group did not change these results ($|\beta| < 0.13, p > 0.20$), with the exception of a marginal interaction between condition and recruitment group for the CIDS ($\beta = -0.45, p = 0.08$). The pre-post change in CIDS score for intervention-offline participants was marginally significant on its own ($t(10) = 1.92, p = 0.08$), tentatively suggesting that the intervention may have led to reduced diabetes self-efficacy for this subset of participants.

**Baseline differences in depression:** Participants recruited online had much higher baseline symptoms of depression than those recruited offline (CESD score of 21.8 vs. 11.2; $F = 8.03, p = 0.01, \eta^2 = 0.17$). We repeated the analyses of positive affect, negative affect, and perceived stress with baseline CESD score (centered) and the interaction between recruitment method and baseline CESD added to the model. If the interaction between recruitment group and condition were significantly reduced, this would suggest that the difference in intervention efficacy between recruitment groups is fully or partially explained by differences in baseline depression.

Baseline depression strongly predicted increases over time in negative affect ($\beta = 0.74, p = 0.02$) and, marginally, perceived stress ($\beta = 0.52, p = 0.06$) but did not predict positive affect ($\beta = -0.13, p = 0.51$). The magnitude of the interaction between treatment group and recruitment method was effectively unchanged for positive affect ($\beta$ changed from $-0.35$ to $-0.43$, new $p = 0.09$) or negative affect ($\beta$ changed from $0.46$ to $0.41$, new $p = 0.15$).

The interaction between treatment group and recruitment method was substantially reduced for perceived stress ($\beta$ changed from $0.62$ to $0.37$, new $p = 0.19$). However, the alternate interaction between depression and recruitment method did not approach significance for this or any other outcome ($|\beta| < 0.12, p > 0.51$). Thus, it does not appear that the differential intervention effects by recruitment group can be explained by their baseline differences in depression.

**Discussion**

We found that an online intervention targeting positive affect skills was able to reduce depression symptoms in adults with type 2 diabetes. The intervention is well suited to broad, inexpensive dissemination, and has the potential to substantially improve quality of life. We demonstrated good retention and adherence, paving the way for future effectiveness research.

Notably, our intervention reduced depression symptoms regardless of participants’ baseline symptom levels. This adds to the growing evidence that interventions based on positive emotions are accessible and effective even for individuals already experiencing depression[75], rather than being restricted to those who are doing well. This points to potential effectiveness in both a preventative and a treatment role.
Unexpectedly, we found that the intervention’s effects were on the negative, rather than the positive, CES-D items; there were also clearer effects on negative affect than on positive affect. We consider this finding a mystery and do not have a clear explanation for it. It does not reduce the potential impact of a reduction in depression symptoms, though it does make the mechanism and nature of the effects less clear.

Feasibility and acceptability

The intervention appears feasible, with a 79% completion rate. Intervention participants visited the website an average of 4.5 times / week, and completed the assigned activities (lessons or skill practice, plus the emotion questionnaire) on nearly all visits. Visit frequency was slightly higher in the emotion-reporting control condition, possibly due to the lower time requirement for control visits. Participants in both groups reported that the daily reminder emails were helpful.

During post-study interviews, participants expressed that they understood the intervention content and found it sensitive and useful. Their comments also suggested that they understood and retained specific intervention concepts, such as mindful awareness and appreciating positive events without denying negative ones. For example, one participant said, “Little things that used to make me angry could become big things and annoy me all day, and now I can just let them go. It’s helped me to be more optimistic, and be present in the moment.” Another said, “These skills can help me see […] Instead of diabetes controlling my life, it’s just a part of my life […] Because I really believe now, having diabetes is a terrible thing, but it’s helped me live a healthier lifestyle that otherwise I wouldn’t have.”

Others commented on the applicability of the intervention to diabetes-related health behaviors, although this was not an explicit focus of the intervention: “Whenever I would get upset, I would stop by the store and buy some kind of pastry. But I haven’t done that lately […] It pretty much taught me how to get through stress without going to my comfort food and overindulging.”

Participants who dropped out generally cited time constraints; none raised issues with the content of the intervention.

Online vs. offline recruitment

The effect of the intervention was considerably stronger among participants recruited over the Internet compared to participants recruited in-person. Online recruits in the intervention condition also showed significant reductions in negative affect and perceived life stress relative to online controls. For positive affect, they improved according to the retrospective measure but not the averaged daily measures.

There are no obvious demographic differences that might explain these differential effects. Participants recruited online were significantly higher on baseline depression symptoms (CES-D 21.8 vs. 11.2), but exploratory analyses suggest that baseline depression differences were not related to intervention effectiveness. It is possible that online recruits were simply more comfortable with using websites or more amenable to learning skills online. It is also possible that online recruits were more actively seeking information or help for their
diabetes compared to the participants who were recruited in person through the clinic, though the two groups did not differ on number of visits to the website.

**Limitations of the current study**

This pilot study provides initial evidence that an online positive emotions intervention can be delivered in an effective, understandable, and sensitive manner to adults with type 2 diabetes, with strong participant engagement and adherence. However, it was not powered to detect downstream changes leading from psychological benefits to health behaviors and health outcomes. Based on the promising psychological outcomes in this study, we are planning a larger intervention study that will collect valid health behavior and health outcome measures, including preventative healthcare utilization, adherence to personalized medication regimens, electronic glucose monitor records, and long-term morbidity and mortality. This will also be a key requirement for rigorous, gold-standard internet-based trials, in order to corroborate participants’ reports of diabetes diagnosis and symptom change.

It will also be important for future studies to test the DAHLIA intervention against a more potent control treatment. Because of the low cost of this intervention, and because individuals typically do not receive interventions of this type (i.e., there is no comparable treatment-as-usual), any degree of efficacy is of potential value. However, comparison with a persuasive placebo control or a psychosocial intervention not based on positive psychology principles will be critical in order to test the proposed importance of positive affect as a mechanism for change, and to guide further intervention development.

The intervention appears to have been effective in a sample recruited online, but less so in a sample recruited in-person from a diabetes clinic. In fact there was some suggestion of reduced diabetes self-efficacy among intervention participants recruited in person, though this was a marginally significant finding and may have occurred by chance. In future research we plan to measure additional variables related to demographics, internet and technology use, learning preferences, and readiness to engage in health behavior change. These will help us determine the cause of this difference and predict which individuals are good candidates for an online intervention and which, if any, might respond negatively.

Participants in this study were paid for completing the daily and pre-post assessments. This increases the per-participant cost of the intervention and reduces the generalizability of our results. However, we felt that payment was important in order to compensate participants for putting time into an untested intervention, and to avoid problems with selective reporting at post-intervention. We are currently pilot testing variants on the intervention that use other methods to enhance retention, including self-tracking feedback and gamification, lower-burden mobile exercises, and peer support.

Finally, this study did not include follow-up assessments that would allow us to assess long-term intervention effects. Longer-term health and psychological follow-up will be included in future studies.
Conclusion

We have demonstrated that individuals with type 2 diabetes find our online positive emotion skills intervention engaging and feasible to complete. The intervention shows potential to reduce symptoms of depression, even in participants with elevated– and in many cases likely clinically significant – levels of baseline depression. The intervention also showed broader psychological efficacy in individuals recruited online, on whom we plan to focus in future research. We are currently working with collaborators to combine our stress-coping and resource-building model of positive emotions with a more direct health behavior adherence intervention[27]. The planned intervention study will gather more definitive effectiveness data, including personalized health behavior adherence and health outcome data with longer-term followup.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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References


Figure 1.
CONSORT flow diagram
Figure 2.
The DAHLIA intervention improves depression and perceived stress for participants recruited online, but not in person.
Figure 3.
The DAHLIA intervention marginally reduces daily negative affect (but not daily positive affect) for participants recruited online, but not in person.
Table 1

Intervention Content

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<thead>
<tr>
<th>Week 1: Positive events</th>
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<tr>
<td><strong>Week 1:</strong> Positive events</td>
<td>Noticing small, everyday positive events. Savoring and capitalizing to increase the impact of a positive event. Potential for positive events to reduce stress and increase coping resources, even for people suffering severe difficulties. Depression-related biases that can make noticing or remembering positive events more difficult. The value of scheduling pleasant events.</td>
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<tr>
<td><strong>Exercises</strong></td>
<td>Daily positive events journal Daily gratitude journal (continues through all weeks of intervention in order to provide an exercise that is simple and attainable even when other material is challenging)</td>
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<th>Week 2: Mindfulness</th>
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<tr>
<td><strong>Week 2:</strong> Mindfulness</td>
<td>Cognitive and emotional benefits of present-focused attention and nonjudgment. Covers both informal mindfulness and brief formal meditation practice. Using present-focused awareness and acceptance to combat rumination.</td>
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<tr>
<td><strong>Exercises</strong></td>
<td>Pick an everyday activity to do mindfully 10-minute mindful breathing recorded meditation (continues through all weeks of the intervention in order to support recognizing positive experiences even in stressful contexts)</td>
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<th>Week 3: Reappraisal</th>
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<td><strong>Week 3:</strong> Reappraisal</td>
<td>Applying positive reappraisal to everyday stressors; disputing excessively negative interpretations and finding “silver linings.” Role of negative cognitions in causing or maintaining depression.</td>
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<tr>
<td><strong>Exercises</strong></td>
<td>Daily reappraisal journal</td>
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<th>Week 4: Strengths and Goals</th>
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<tr>
<td><strong>Week 4:</strong> Strengths and Goals</td>
<td>How to recognize personal strengths. Support for acknowledging strengths even when feeling bad about oneself. Techniques for setting goals that are appropriately challenging but still feasible. Finding goals that will provide enjoyment or mastery experiences.</td>
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<tr>
<td><strong>Exercises</strong></td>
<td>Daily strengths journal (record ways you used a personal strength or talent) Select a goal for the week and record progress daily</td>
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<th>Week 5: Acts of Kindness</th>
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<tr>
<td><strong>Week 5:</strong> Acts of Kindness</td>
<td>The personal and relational benefits of performing small acts of kindness, even when under stress. Small prosocial acts that can be performed even if relatively socially isolated.</td>
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<tr>
<td><strong>Exercises</strong></td>
<td>Do something nice for someone else each day and record it in a daily kindness journal</td>
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Table 2
Pre- and Post-intervention outcome scores (mean and SD).

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<tbody>
<tr>
<td><strong>CES-D (Depression)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotion reporting</td>
<td>17.1 (15.4)</td>
<td>17.7 (14.7)</td>
<td>$\beta = -0.21, p = .05$</td>
</tr>
<tr>
<td>DAHLIA intervention</td>
<td>16.9 (11.6)</td>
<td>12.6 (14.7)</td>
<td></td>
</tr>
<tr>
<td><strong>PSS (Perceived Stress)</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Emotion reporting</td>
<td>1.84 (.84)</td>
<td>1.72 (.80)</td>
<td>$\beta = -0.13, p = .31$</td>
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<tr>
<td>DAHLIA intervention</td>
<td>1.71 (.65)</td>
<td>1.51 (.58)</td>
<td></td>
</tr>
<tr>
<td><strong>Daily positive affect</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Emotion reporting</td>
<td>5.13 (1.94)</td>
<td>4.64 (2.13)</td>
<td>$\beta = -0.09, p = .46$</td>
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<tr>
<td>DAHLIA intervention</td>
<td>5.10 (1.39)</td>
<td>4.77 (1.42)</td>
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</tr>
<tr>
<td><strong>Daily negative affect</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Emotion reporting</td>
<td>2.69 (1.25)</td>
<td>2.39 (.86)</td>
<td>$\beta = -0.15, p = .32$</td>
</tr>
<tr>
<td>DAHLIA intervention</td>
<td>2.37 (1.08)</td>
<td>2.08 (1.00)</td>
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</tr>
</tbody>
</table>

* Regression parameter for condition predicting post-intervention score while controlling for pre-intervention score.
Table 3
Pre- and Post-intervention outcome scores for participants recruited online only (mean and SD).

<table>
<thead>
<tr>
<th></th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
<th>Treatment effect*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CES-D (Depression)</strong></td>
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<td></td>
</tr>
<tr>
<td>Emotion reporting</td>
<td>22.9 (17.6)</td>
<td>22.8 (16.4)</td>
<td>$\beta = -0.34, p = .02$</td>
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<td>DAHLIA intervention</td>
<td>20.9 (11.5)</td>
<td>13.7 (9.58)</td>
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</tr>
<tr>
<td><strong>PSS (Perceived Stress)</strong></td>
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</tr>
<tr>
<td>Emotion reporting</td>
<td>1.88 (1.02)</td>
<td>1.97 (.88)</td>
<td>$\beta = -0.43, p = .01$</td>
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<tr>
<td>DAHLIA intervention</td>
<td>2.09 (.58)</td>
<td>1.50 (.69)</td>
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<td><strong>Daily positive affect</strong></td>
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</tr>
<tr>
<td>Emotion reporting</td>
<td>4.54 (1.81)</td>
<td>4.17 (2.04)</td>
<td>$\beta = 0.14, p = .40$</td>
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<td>DAHLIA intervention</td>
<td>4.68 (1.48)</td>
<td>4.76 (1.43)</td>
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<tr>
<td><strong>Daily negative affect</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Emotion reporting</td>
<td>3.06 (1.44)</td>
<td>2.56 (1.04)</td>
<td>$\beta = -0.32, p = .09$</td>
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<tr>
<td>DAHLIA intervention</td>
<td>2.70 (1.29)</td>
<td>1.78 (.70)</td>
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</tr>
</tbody>
</table>

* Regression parameter for condition predicting post-intervention score while controlling for pre-intervention score and condition X offline recruitment interaction (i.e., the parameter shown reflects effect of condition among online recruits only).

[Note for reviewers: We used this statistic for consistency with the tests reported in the text. We also ran the tests by excluding offline recruits and using a single condition parameter, and the results were essentially unchanged.]