Reduction of Bodily Pain in Response to an Online Positive Activities Intervention

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Abstract: Inducing temporary positive states reduces pain and increases pain tolerance in laboratory studies. We tested whether completing positive activities in one's daily life produces long-term reductions in self-reported bodily pain in a randomized controlled trial of an online positive activities intervention. Participants recruited via the Web were randomly assigned to complete 0, 2, 4, or 6 positive activities administered online over a 6-week period. Follow-up assessments were collected at the end of 6 weeks and at 1, 3, and 6 months postintervention. We used linear mixed effects models to examine whether the intervention reduced pain over time among those who had a score <67 on the bodily pain subscale of the Short Form-36 at baseline (N = 417; pain scores range from 0 to 100; higher scores indicate less pain). Mean pain scores improved from baseline to 6 months in the 2-activity (55.7 to 67.4), 4-activity (54.2 to 71.0), and 6-activity (50.9 to 67.9) groups. Improvements were significantly greater ($P < .05$) in the 4-activity and 6-activity groups than in the 0-activity control group (54.1 to 62.2) in unadjusted and adjusted models. This study suggests that positive activities administered online can reduce bodily pain in adults with at least mild to moderate baseline pain.

Perspective: This study demonstrates that teaching people simple positive activities can decrease reported levels of bodily pain; moreover, these activities can be administered over the internet, a potential avenue for broadly disseminating health interventions at relatively low costs and with high sustainability.

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Key words: Pain management, internet, intervention studies, mind-body therapies, happiness.
of positive psychology. Positive psychology focuses on promoting health by increasing positive emotions and behaviors rather than treating negative symptoms.\textsuperscript{29,31} Numerous positive psychology studies have shown that well-being can be increased through a variety of simple, evidence-based positive activities.\textsuperscript{19,31,32} Examples of positive activities that improve well-being include exercises involving gratitude, kindness, optimism, mindfulness, identifying and using personal strengths, reflecting on good things, forgiveness, or some combination thereof.\textsuperscript{19,32} The commonality across effective positive activities is that they increase one or more core components of subjective well-being: feelings of pleasure, engagement with the surrounding environment, and/or meaning in one’s life.\textsuperscript{31}

Studies testing the health effects of positive activities have mostly examined outcomes such as well-being or depressive symptoms, and report improvements in these outcomes in both depressed and nondepressed populations.\textsuperscript{32} Observational and experimental evidence suggests that completing positive activities may also reduce pain, in that experiencing pleasurable engagement with the environment (eg, feeling joy, excitement, or contentment) is associated with numerous positive physical health outcomes, including reduced pain and greater pain tolerance.\textsuperscript{26,33} For example, in adults with chronic pain in a long-term facility, watching a funny movie was associated with decreased self-reported pain and decreased pain medication.\textsuperscript{1} An observational study also found that patients with high self-reported levels of positivity had better functioning (eg, faster walking speed) 2 years following a hip fracture than those who reported less positivity when the fracture occurred.\textsuperscript{8} Previous studies examining the impact on pain of being positive have examined the short-term impact of completing a single positive activity in an experimental setting or relied on observational data to examine the association of naturally occurring positive states with outcomes. We are aware of no prior studies that test the long-term impact of completing multiple positive activities in individuals with at least mild to moderate pain.

The current study addresses this gap using data from a randomized controlled trial designed to test the effect of an online positive activities intervention on depressive symptoms in a convenience sample of internet users who visited a positive psychology Web site.\textsuperscript{27} Volunteers, regardless of depressive state, were randomly assigned to complete 0, 2, 4, or 6 evidence-based positive activities over a 6-week period. In this secondary data analysis, we examine the effect of the online positive activities intervention on bodily pain in the subset of participants who reported at least mild to moderate pain at baseline. We hypothesize that participants randomly assigned to complete 2, 4, or 6 positive activities will show greater reductions in bodily pain after the intervention compared with those assigned to a 0-activity control group.

### Methods

#### Study Design

We conducted secondary analyses of data from a randomized controlled trial of an online positive activities intervention to examine change in bodily pain among participants who reported bodily pain at baseline. The Institutional Review Board at the University of Pennsylvania approved the study protocol.

#### Parent Study

Data were drawn from a parent study designed to test the feasibility of disseminating a positive activities intervention online and to test whether the number of activities offered to participants (0, 2, 4, or 6) affected adherence and outcomes.\textsuperscript{27} The online version of the intervention was adapted from an established Positive Psychotherapy (PPT) program that included multiple activities delivered by a trained clinician in group psychotherapy sessions over multiple weeks.\textsuperscript{27,30} The goal of the online parent study was to provide “proof of concept” that the activities in the PPT program could be delivered more simply, without a clinician or in-person interactions, and still be effective. To provide maximum comparability between the online study and the original PPT program, activity instructions were adapted so that they could be delivered online, but the overall content and order of activities from the original program were preserved. Full details of the parent study procedures and primary study findings are available elsewhere.\textsuperscript{27} Further details pertinent to this secondary analysis are provided below.

#### Participants

Participants were recruited for the parent study via a Web-based research portal hosted by the University of Pennsylvania’s Positive Psychology Center and advertised in the book Authentic Happiness.\textsuperscript{28} The parent study was described as a research study on positive psychology exercises and was accessible through links placed on the websites www.authentichappiness.org and www.ppresearch.sas.upenn.edu. Participants included all internet users who voluntarily visited the research portal, reviewed a description of the parent study, and consented to participate by providing an electronic signature. No additional inclusion or exclusion criteria were required to enroll in the parent study.

The purpose of the current study was to examine the impact of the intervention on bodily pain, which was assessed as a secondary variable. Because the presence of pain was not an inclusion requirement for the parent study, it was necessary to restrict the analytic sample for the current study to those with at least mild to moderate pain at baseline to be able to examine change in pain over time (see Study Measures for details on how pain was measured).
Procedures

Participants who consented to participate completed a baseline assessment of all study measures and were then randomly assigned to complete 0, 2, 4, or 6 positive activities over the next 6 weeks. Participants assigned to one of the positive-activity groups were also presented with the instructions for the first positive activity upon completing the baseline assessment and were asked to practice the activity over the next week. Participants in all groups were sent weekly e-mail reminders to return to the study site to complete study assessments. Participants in the 2-, 4-, and 6-activity groups were also given standardized instructions for the next activity after they completed each weekly assessment. Participants were expected to complete assigned activities independently and offline.

Although all participants received an e-mail every week to complete study measures, participants only received instructions for the number of activities they were assigned to complete (0, 2, 4, or 6) based on their study group. For example, participants assigned to the 2-activity group were given instructions for the first activity the first week, the second activity the second week, and then received weekly e-mail reminders to return to the study site to complete additional study assessments for the remaining 4 weeks of the study. Upon returning for assessment after completing the last activity for the group to which they were assigned, participants were told that they would not receive additional activities; they were not told explicitly to continue or discontinue practicing the activities they had learned during the remainder of the 6-week assessment period. At the end of the assessment period, however, participants in the 2-, 4-, and 6-activity groups were instructed to continue or discontinue the activities as they wished, and they were advised to customize the activities to their needs and preferences as needed.

To assess intervention adherence, each weekly assessment asked participants in the positive-activity groups whether they used each activity as instructed in the previous week. The total number of activities used across the 6-week intervention period served as the measure of adherence. All participants were e-mailed 1, 3, and 6 months postintervention to complete additional follow-up assessments.

A total of 6 positive activities were included in this study and were presented in the same fixed order as in the group PPT program from which the online program was adapted (see Table 1). All 6 activities have yielded improvements in well-being or depressive symptoms when used individually or as part of a multi-activity intervention. Activities were brief exercises that participants could complete during the course of the week. For example, the first activity, Three Good Things, instructed participants to identify and reflect on 3 positive things that they experienced each day over the next week and record them in a journal. This exercise is intended to increase gratitude and train participants to focus attention on positive, rather than negative, events. A previous study demonstrated that completing this activity for 1 week increased subjective well-being and reduced depressive symptoms 1 month later, with effects remaining at 6 months, most likely because almost everyone voluntarily continues to use the activity after the assigned time frame. Full descriptions of all 6 activities are available elsewhere.

Study Measures

The outcome in the current analysis is the bodily pain subscale of the Short Form 36 (SF-36), which was administered as part of the baseline assessment at the end of the 6-week intervention and at 1, 3, and 6 months postintervention. This scale includes 2 items that assess how much bodily pain one has had (none, very mild, mild, moderate, severe, very severe) and how much pain interfered with one’s normal work (not at all, a little bit, moderately, quite a bit, extremely) in the past 4 weeks. Responses are summed across items and converted to a scale from 0 to 100 according to an established algorithm. Higher scores indicate less pain and/or less interference of pain with normal activities, with 0 indicating no pain and 100 indicating no pain and 0 indicating very severe pain that interferes with normal activities to an extreme extent. The bodily pain subscale has shown excellent internal reliability, test-retest reliability, and convergent and discriminant validity in SF-36 validation studies. For the current analysis, we limited the analytic sample to those with at least mild to moderate pain at baseline, thereby including those with baseline bodily pain scores in the top third of the distribution (ie, the third with worst pain scores).

Demographic and clinical variables collected at baseline were used as control variables in this analysis. Demographic control variables included age, gender, marital status, education, and income (treated as a continuous variable in models). Clinical control variables included whether participants reported that they were depressed at baseline and whether participants reported that they were undergoing any kind of treatment for a mental health problem at baseline. The SF-36 mental health subscale was also included as a general indicator of mental health status. This measure was available for all time points and was included in the models.

Table 1. Summary of Positive Activities

<table>
<thead>
<tr>
<th>Week</th>
<th>Positive Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Three good things: Identify 3 things that went well each day and reflect on why they occurred.</td>
</tr>
<tr>
<td>2</td>
<td>Strengths: Complete a survey that identifies one’s strengths and then use a top strength each day.</td>
</tr>
<tr>
<td>3</td>
<td>Gratitude visit: Write a letter of gratitude and read it aloud to the recipient.</td>
</tr>
<tr>
<td>4</td>
<td>Savoring: Focus intensely on positive experiences 2 to 3 times each day.</td>
</tr>
<tr>
<td>5</td>
<td>Active-constructive responding: Practice responding positively to good news shared by others.</td>
</tr>
<tr>
<td>6</td>
<td>Life summary: Write a summary of how one wants to be remembered.</td>
</tr>
</tbody>
</table>
in the models as a time-varying predictor to control for changes in mental health status over time.

**Statistical Analyses**

Analysis of variance and chi-square tests were used where appropriate to assess differences in baseline demographic and clinical variables between the intervention and control groups. Variables that differed across the 0-, 2-, 4-, and 6-activity groups using $\alpha = .05$ were included as covariates in adjusted models.

Linear mixed effects models were used to identify baseline demographic and clinical variables that were also related to bodily pain. Bodily pain was modeled as a function of each variable in separate models. Variables that were statistically significantly related to bodily pain using $\alpha = .05$ were used as covariates in later analyses.

To determine an appropriate strategy to account for missing data on follow-up assessments, analyses were performed to identify baseline variables that were related to whether an individual completed all postbaseline assessments. For each baseline variable, univariate logistic regression models were fit using completer status (completed all time points vs missing at least 1 time point) as the outcome. Variables that were statistically significant predictors of completer status were used as control variables in later analyses to account for unmeasured confounders for not completing the postbaseline assessments. These types of adjustments have been used to reduce bias and increase precision in the estimates that can be caused by data that are not missing at random.14,16

Linear mixed effects models were used to assess the impact of the intervention on bodily pain over time (baseline, postintervention, 1 month, 3 months, and 6 months). Change from baseline of bodily pain scores was modeled as a function of time (continuous) and the interaction of activity group (4-level categorical) and time (continuous). An adjusted model was also fit by adding variables that were significantly different across activity groups, were related to bodily pain, or were related to completing all assessments versus not. We conducted additional analyses to determine whether the effect of the intervention varied by participant demographic or clinical characteristics. We also conducted sensitivity analyses to determine whether the effect of the intervention varied when the sample was restricted to participants with data at all time points or expanded to include participants with less pain at baseline. Statistical significance was determined using $\alpha = .05$ (2-sided). All analyses were performed using Stata, version 12.14

Cohen’s d effect size estimates were computed for the change in raw bodily pain scores from baseline to 6 months for the 2-, 4-, and 6-activity groups compared to the 0-activity control group.

**Results**

**Sample Characteristics**

The parent study enrolled 1,364 participants. Three participants who had very extreme scores for most of the collected measures were excluded from analyses. Restricting analyses to those who reported at least mild to moderate pain at baseline resulted in the inclusion of those with a baseline bodily pain score of 67 or less (N = 417), that is, those in the worst tertile of pain scores. Of the 417 participants in the analytic sample at baseline, 35.5% had complete bodily pain data for all study time points (48.2% at postintervention, 45.8% at 1 month, 42.9% at 3 months, and 37.9% at 6 months). These response rates were typical of those observed in longitudinal online studies.7 Univariate analyses indicated that the likelihood of completing all study time points was not associated with baseline bodily pain ($P = .54$), but was associated with older ages (odds ratio [OR] = 1.02, 95% confidence interval [CI] = 1.00, 1.04) and better mental health status as defined by the baseline mental health SF-36 subscale (OR = 1.02, 95% CI = 1.01, 1.03). Response rates were also higher in the 0-activity control group than in the 2-, 4-, or 6-activity groups. For example, 60.6% of participants in the 0-activity control group responded at the end of the 6-week intervention period, compared with 41.2%, 41.3%, and 49.5% in the 2-, 4-, and 6-activity groups, respectively. This pattern was consistent across the remaining time points in our analytic sample (data not shown) and was similar to patterns observed in the full sample of the parent study.27

The sample in this analysis had a mean age of 46 and was predominantly female (82.5%), married (56.8%), and college-educated (71.3%) (Table 2). Marital status, income, SF-36 mental health scores, and rates of depression at baseline varied across the 4 study groups (Table 2). Several baseline variables were associated with bodily pain. Specifically, significantly more bodily pain was reported by participants who were female ($β = −5.12, 95% CI = −8.79, −1.45$), reported being depressed at baseline ($β = −7.24, 95% CI = −10.05, −4.44$), and were undergoing mental health treatment at baseline ($β = −4.58, 95% CI = −7.39, −1.77$). Significantly less baseline pain was reported by those with at least a 4-year college degree ($β = 3.46, 95% CI = .16, 6.77$) and higher incomes ($β = 1.92, 95% CI = 1.12, 2.72$).

**Intervention Adherence**

On average, participants completed roughly half the activities they were assigned to complete. The mean number of positive activities participants reported that they completed as instructed was .9 (standard deviation [SD] = .7) in the 2-activity group, 1.9 (SD = 1.4) in the 4-activity group, and 2.7 (SD = 2.1) in the 6-activity group.

**Effects of the Intervention on Bodily Pain Over Time**

Mean bodily pain scores in this sample were 53.8 (SD = 14.6) at baseline, 62.4 (SD = 22.6) at 6 weeks postenrollment, 64.9 (SD = 22.8) at the 1-month follow-up, 64.0 (SD = 24.5) at 3 months, and 66.4 (SD = 21.8) at 6 months. Raw mean bodily pain scores improved over time in all study groups (Fig 1). The largest improvement occurred in the 6-activity group, whose mean pain scores
were 50.9 at baseline and 67.9 at 6 months. The next largest improvement was in the 4-activity group (54.2 at baseline, 71.4 at 6 months), followed by the 2-activity group (55.7 at baseline, 67.4 at 6 months) and the 0-activity control group (54.1 at baseline, 62.2 at 6 months). In the unadjusted model that included study group, time, and the interaction of study group and time, the overall interaction between study group and time was statistically significant ($P = .018$; Table 3). The overall interaction between study group and time remained statistically significant after adjusting for control variables ($P = .033$; Table 3).

We examined the individual interaction terms between each activity group and time in the adjusted models to identify whether pain improved significantly more in each of the 2-, 4-, and 6-activity groups than in the 0-activity control group. There was significantly greater improvement in pain over time for the 4-activity group ($\beta = 2.19$, 95% CI = .38, 4.00) and the 6-activity group ($\beta = 2.31$, 95% CI = .54, 4.08) but not for the 2-activity group ($\beta = 1.13$, 95% CI = −.71, 2.97).

Compared to change in bodily pain from baseline to 6 months postintervention in the 0-activity control group, the intervention had only a small effect in the 2-activity group (Cohen’s $d = .3$) compared to a medium effect in the 4-activity (Cohen’s $d = .4$) and 6-activity groups (Cohen’s $d = .6$).

We conducted sensitivity analyses to assess bias due to missing data by fitting the unadjusted and adjusted models using only those participants who completed all postbaseline assessments ($n = 148$). The overall impact of the intervention was borderline statistically significant in both models (Table 3). Estimated interactions between individual activity groups and time were similar in magnitude to the models using all participants regardless of what assessments were completed. We also reran the models using a lower threshold for pain that corresponded with the mean reported pain level at baseline in the overall sample (bodily pain score $\leq 78$). The effects of the intervention were attenuated but remained statistically significant for the 4- and 6-activity groups (Table 3).

**Discussion**

Among adult internet users who participated in a randomized controlled trial of a positive activity intervention and reported at least mild or moderate bodily pain at baseline, those assigned to complete at least 4 positive activities reported less bodily pain after the intervention compared to those in a 0-activity control group. The effect depended on how many positive activities people were assigned to complete. Participants assigned to the 4- and 6-activity groups experienced significant pain reduction compared to the 0-activity group. Lower pain scores were observed in the 0-activity control group, with effect sizes ranging from small to medium. The 2-activity group reported a small effect size, indicating less pain improvement compared to the control group. Despite the small effect size, the intervention showed promise in reducing bodily pain in internet users, with the greatest improvements seen in the 4- and 6-activity groups.
Our results have potential implications for the field of pain management. In light of increasing health care costs and the overwhelming burden of chronic pain, there is a need for practical pain-management strategies that people can use to engage in successful self-management. This study demonstrates that teaching people simple positive activities can decrease reported levels of bodily pain. Moreover, this study demonstrates that positive activities can be disseminated over the internet, which is seen as a potential avenue for disseminating health interventions to a wide audience at relatively low costs and with high sustainability. Additional work may be needed to increase and maintain engagement with positive activities delivered online, given that we observed lower response rates among participants assigned to do activities than among assessment-only controls, and participants reported completing approximately half the number of activities assigned to their group. In the current study, activities were administered in a basic online format that simply gave people access to written instructions for activities that were then completed offline, without further elaboration or follow-up. To maximize the uptake, maintenance, and impact of positive activities interventions, it may be necessary to deliver them using an interface that actively engages participants as they complete each activity and allows people to log their performance, reflect on their response to activities, and connect with others who are completing the activities. Interactive positive mobile apps with features such as these have actually been developed for commercial use and have been voluntarily purchased by thousands of people. Moreover, people who used an app called Live Happy showed an improvement in mood over time, especially for those who completed activities more frequently and for those who completed a bigger variety of activities.

Our results suggest that evidence-based positive activities, even when administered in a very basic online format, have the potential to enhance pain self-management. Given that our sample included internet users who reported bodily pain rather than people seeking health care for chronic pain, future research should explore the use of positive activities as part of comprehensive pain management plans recommended to patients by health care professionals who treat chronic pain. To facilitate the use of positive activities in pain management, work is needed to determine which types of pain benefit most from these activities, how best to incorporate these activities into a patient’s overall pain management plan, how to make the activities maximally accessible to patients, how to encourage adherence to the activities, and how to make it easy for health care professionals to use them with their patients. Positive activities interventions using activities similar to those in this study have been used in patients with acute pain in controlled research settings. In contrast, our web-based intervention study demonstrates the impact of multiple evidence-based positive activities, delivered over the course of 6 weeks and used by people in their everyday lives, on bodily pain immediately following the intervention and 6 months later.

Our findings were predicted by and provide empirical support for the biopsychosocial model of pain, which suggests that the pain experience is influenced by both psychosocial and biological factors. Our results are also consistent with experimental studies in which inducing positive mood caused short-term decreases in pain or increases in pain tolerance. For example, one recent study demonstrated that inducing optimism by having participants imagine and write about a future best possible self caused lower ratings of pain intensity in response to a pain induction task.

Our study goes beyond previous work in important ways. Prior experimental studies have demonstrated short-term effects of inducing positive states on acute pain or increases in pain tolerance. For example, one recent study demonstrated that inducing optimism by having participants imagine and write about a future best possible self caused lower ratings of pain intensity in response to a pain induction task. For example, one recent study demonstrated that inducing optimism by having participants imagine and write about a future best possible self caused lower ratings of pain intensity in response to a pain induction task.

Table 3. Sensitivity Analyses Comparing Effects of the Intervention for All Participants, Those Who Completed All Assessments, and Those Who Had a Pain Score ≤78 at Baseline

<table>
<thead>
<tr>
<th>Effect of the Intervention</th>
<th>N</th>
<th>Interaction</th>
<th>95% CI</th>
<th>P</th>
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<tbody>
<tr>
<td>Unadjusted model</td>
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<td></td>
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<tr>
<td>Analytic cohort*</td>
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<td>.018</td>
<td></td>
<td></td>
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<tr>
<td>2 activities</td>
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<tr>
<td>4 activities</td>
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<td>.63, 4.25</td>
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<td>6 activities</td>
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<td>.62, 4.20</td>
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<tr>
<td>Completers only</td>
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<td>Pain score ≤78 at baseline</td>
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<td>−.93, 3.43</td>
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<td>2.10</td>
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<td>Pain score ≤78 at baseline</td>
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<td>2 activities</td>
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<td>4 activities</td>
<td>1.61</td>
<td>.22, 3.00</td>
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<tr>
<td>6 activities</td>
<td>1.88</td>
<td>.48, 3.28</td>
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</tr>
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</table>

*Included those who had a pain score ≤67 at baseline.
†Included those who had a pain score ≤67 at baseline and completed all study assessments.
‡Adjusted for age, sex, marital status, education, income, self-reported depression at baseline, undergoing mental health treatment at baseline, and time-varying SF-36 mental health score.
cardiovascular disease, newly diagnosed human immuno-deficiency virus, and schizophrenia and in those undergoing smoking cessation, demonstrating that they can be used effectively in clinical populations. There is also evidence that positive activities can be successfully disseminated in a variety of ways, including self-directed methods such as the internet or self-help books, as well as in-person facilitation in one-on-one or group-based settings, thereby allowing flexibility in how positive activities can be integrated into pain management plans. Our results provide evidence that the use of positive activities for pain management should be explored further in the pursuit of safe, effective, and affordable nonpharmacologic pain interventions.

We acknowledge several limitations of this study. Low response rate is a potential limitation, as 36% of participants completed all time points. The overall response rates we observed, however, were typical of those observed in longitudinal online studies. We also conducted extensive sensitivity analyses to show that the effects of the intervention were robust, finding that improvements in bodily pain were similar when we restricted analyses to those who completed study measures at all time points, included people with less bodily pain at baseline, and controlled for potential confounding variables. Another limitation is that the study included a convenience sample of internet users who visited a positive psychology website and agreed to participate in a study to learn positive psychology exercises, which may limit the generalizability of the study findings. Given that the original study was not designed to test the intervention’s effect on bodily pain, information about the duration, intensity, and source of pain experienced in this sample is not available. Additional research is needed to determine the extent to which this type of intervention helps people with specific acute and chronic pain conditions. Because the order of the activities was not randomized across participants, it is also unclear whether the greater effects observed in the 4- and 6-activity groups were due to the overall dose of positive activities or to aspects of the specific activities provided to those groups. Finally, this study does not provide definitive information about the mechanisms by which positive activities reduce bodily pain. In the current study, the intervention’s effect on pain persisted after controlling for baseline depression and changes in mental well-being over time. Future work is needed to determine whether completing positive activities decreases pain through mechanisms other than by improving overall mental health status, such as by increasing pain coping self-efficacy, decreasing pain catastrophizing, increasing physical activity, or strengthening social ties.

In conclusion, our study demonstrates that positive activities disseminated online can reduce bodily pain in an adult sample of internet users. This work highlights the need to develop such activities for use as part of comprehensive pain management programs and to test their utility for easing the burden of chronic pain.

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