Effects of a Tailored Positive Psychology Intervention on Well-Being and Pain in Individuals With Chronic Pain and a Physical Disability

A Feasibility Trial

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Objectives: To determine the feasibility, acceptability, and efficacy of a computer-based positive psychology intervention in individuals with a physical disability and chronic pain.

Methods: Individuals with spinal cord injury, multiple sclerosis, neuromuscular disease, or postpolio syndrome and chronic pain were randomly assigned to a positive psychology or a control condition. Participants in the intervention group were instructed to practice 4 personalized positive psychology exercises. Participants in the control group were instructed to write about life details for 8 weeks. Participants completed online well-being and pain-related questionnaires at baseline, posttreatment, and at the 2.5-month follow-up, and rated treatment satisfaction at posttreatment.

Results: Ninety-six participants were randomized and 68 (70%) completed follow-up assessments. Participants in the positive psychology intervention group reported significant pretreatment to posttreatment improvements in pain intensity, pain control, pain catastrophizing, pain interference, life satisfaction, positive affect, and depression. Improvements in life satisfaction, depression, pain intensity, pain interference, and pain control were maintained to the 2.5-month follow-up. Participants in the control group reported significant pretreatment to posttreatment improvements in life satisfaction, and pretreatment to follow-up improvements in pain intensity and pain control. Significant between-group differences, favoring the treatment group, emerged for pretreatment to posttreatment improvements in pain intensity and pain control. Participants were similarly satisfied with both treatments.

Discussion/Conclusions: The results support the feasibility, acceptability, and potential efficacy of a computer-based positive psychology intervention for improving well-being and pain-related outcomes in individuals with physical disabilities and chronic pain, and indicate that a full trial of the intervention is warranted.

Key Words: chronic pain, happiness, depression, treatment efficacy

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Chronic pain is a common consequence of many diagnoses associated with physical disabilities, including spinal cord injury (SCI), multiple sclerosis (MS), neuromuscular disease (NMD), and postpolio syndrome (PPS). Chronic pain has been defined as pain that persists beyond the resolution of the acute cause of pain and expected period of healing.[1] Estimates of the incidence of chronic pain range from 65% to 80% for SCI,[2–6] 44% to 75% for MS,[7,8] about 73% for NMD,[9] and about 91% for PPS.[10] Managing the long-term physical, psychological, and social consequences of both an impairing physical condition and chronic pain potentially poses a dual burden for the individual. This burden can create an added risk for psychological morbidity[8,11,12] and reduced well-being,[13–16] and also place significant limitations on physical and social functioning.[4,17]

Research shows that pharmacological,[16,18] nonpharmacological,[19–21] and psychological[22–24] treatments of chronic pain can provide some relief for some individuals with physical disabilities. However, all of the available treatments have limitations, which include (1) a lack of meaningful efficacy for the majority of individuals, (2) absence of evidence for long-term beneficial effects, (3) high costs, and (4) for some treatments, significant side effects.[18,25,26] Limited access to potentially beneficial treatments, including psychosocial interventions, also presents a significant barrier to pain relief.[27] Therefore, there continues to be a compelling need to identify additional effective treatments for chronic pain.

Positive psychology interventions focus on creating and enhancing subjective well-being (ie, a combination of life satisfaction and the frequency of both positive and negative affect[28]). Positive psychology complements the traditional study of pathology: rather than focusing on and targeting individuals' deficits and vulnerabilities, positive psychology promotes the understanding of psychosocial strengths and resources such as gratitude, optimism, purpose in life, self-efficacy, kindness, and social relationships.[29] Randomized controlled trials of positive psychology interventions have included writing letters of gratitude,[30–32] counting one's blessings,[33–35] practicing optimism,[30,31,36,37] performing acts of kindness,[38,39] meditating on positive feelings toward others,[40] and a focus on and use of one's signature strengths.[32] Results of 2 meta-analyses of positive psychology interventions concluded that they significantly increase subjective and psychological well-being (mean effect size range, $r = 0.20$ to 0.34) and

decrease depressive symptoms (mean effect size range, $r = 0.23$ to 0.31),[41,42] and that these benefits maintain for up to 6 months.[32,42] Positive psychology interventions have been effectively applied to the general population and also to individuals with depression,[41] anxiety disorder,[43] offending behavior,[44] and alcohol misuse.[45]

Although research supporting the benefits of positive psychology interventions is growing, there remains a significant knowledge gap on the potential for positive psychology interventions to benefit individuals with physical disabilities and chronic pain. For example, even though research shows that positive psychological resources (such as positive emotions, optimism, rewarding activities, purpose in life, and spirituality) are associated with greater well-being in individuals with an impairing physical condition,[46–49] it is unclear whether positive psychology interventions can be translated and effectively applied to individuals with chronic pain secondary to a physical disability. The overall objective of this study was to address this knowledge gap by determining the efficacy, feasibility, and acceptability of a computer-based tailored intervention based on positive psychology to enhance well-being and reduce chronic pain in individuals with a physical disability. A computer-based intervention was chosen because it is linked to better accessibility, sustainability, standardization, and lower costs of an intervention, and fosters anonymity and empowerment for participants.[50–52] A tailored intervention was used as it has been found to lead to a greater effectiveness of the intervention.[53]

The specific aims of this study were to (1) evaluate the feasibility of study design and procedures, (2) assess the acceptability of the intervention, (3) determine the effects of the intervention on a number of well-being and pain-related outcomes, (4) determine the sample size to detect significant effects for the outcomes impacted by the intervention in a larger efficacy trial, (5) calculate the intervention dose, and (6) evaluate the utility of measurement instruments for assessing the effects of the intervention.

METHODS

Study Design, Participants, and Procedures

We pilot tested a computer-based tailored intervention based on positive psychology by a randomized (1:1) parallel-group controlled, single-blind trial in individuals with chronic pain secondary to a physical disability. The project was approved by the Human Subjects Division at the University of Washington.

A sample size goal of 66 was deemed large enough to provide reliable effect size estimates.[54] Given an anticipated 35% attrition rate found in Internet-based interventions for anxiety and depression,[55] we therefore sought to enroll at least 102 participants.

Participants were recruited through the University of Washington's Rehabilitation Medicine Research Registry. One hundred registry individuals from each of 4 diagnostic groups SCI, MS, NMD, and PPS (total N = 400) were randomly selected and invited to participate. In addition, an advertisement for participation in this pilot study was uploaded on the National MS Society Web page (http://www.nationalmssociety.org/index.aspx). An approach letter, a "Frequently Asked Questions" (FAQ) sheet, and a consent information statement were sent to all prospective participants. The approach letter informed individuals to contact the first author if they were interested in participating or if they had any questions after review of the FAQ sheet and consent information statement, and that the first author would call in 2 to 3 weeks if the potential participant did not respond to the study invitation.

Interested individuals were screened by telephone for eligibility. Inclusion criteria were as follows: being 18 years of age or older, reporting an average pain intensity in the past week of ≥ 4 on a 0 to 10 Numeric Rating Scale (NRS) on at least half the days in the past 4 weeks, having an ability to speak, read, and write English, and having Internet access on a weekly basis for at least 30 minutes. Exclusion criteria were as follows: currently participating in any psychosocial treatment (eg, psychotherapy, self-hypnosis training, biofeedback) once or more in the past month, reporting a history of hospitalization for psychiatric reasons within the past year, and having severe cognitive impairment defined as ≥ 1 errors on the Six-Item Cognitive Impairment Test.[56] Eligible participants who provided consent received a link with access to the online baseline questionnaire. Participants who completed the baseline questionnaire online were then randomized to either the intervention group or the active control group using a computerized random number algorithm generated by the first author using Excel with a 1:1 allocation and blocks of 4 stratified by sex and disability diagnosis (ie, SCI, MS, NMD, and PPS).

Interventions

To tailor the positive psychology intervention, participants assigned to the intervention group first completed an adapted version of the Person-Activity Fit Diagnostic (PAFD)[57] online. The PAFD asks respondents to rate 10 different activities (eg, acts of kindness, socializing, physical activity, meditation) on 5 dimensions ("It feels natural doing it," "I enjoy doing it," "I value and identify myself with doing it," "I would feel guilty not doing it," and "I would do it because someone else wants me to do it") on 7-point Likert scales (ranging from "Not at all" to "Very much"). The PAFD responses were scored on the basis of the PAFD guidelines.[57] The 4 activities that received the highest ratings were identified as those that best matched the participants' interests. Five participants did not return the PAFD and thus received a standardized version of 4 exercises with the strongest evidence supporting their efficacy based on previous studies. The 10 exercises were developed by the study authors on the basis of a review of the literature[33,37,47,58–60] and are summarized in Table 1 (the 4 exercises chosen for the standardized treatment are denoted by an asterisk).

The 4 exercises selected for each participant were then sent by email each on 1 to maximal 2 pages attached as a portable document format and imbedded in the email text. Research in the general population indicates that as much of an increase in subjective well-being has been observed among individuals who engaged in positive psychology exercises only once a week compared with those who performed the exercises several times in a week.[61] In addition, meta-analyses of positive psychology interventions recommend, on the basis of moderation analyses, to deliver the intervention for at least 4 weeks, but preferably 8 weeks or longer.[42] We therefore instructed participants to perform at least one of the exercises for at least 15 minutes, at least 1 day every week including on "bad" days (defined as days with higher than average levels of pain intensity or feeling "down in the dumps") for 8 weeks. Participants were told

TABLE 1. Participants Randomized Into the Intervention Group Were Tailored to 4 of the Following 10 Exercises

Title (Frequency in %)	Description
Kindness (83%)*	Performing good deeds for other people, whether friends or strangers, either directly or anonymously, either spontaneously or planned
Gratitude (54%)*	Counting blessings, appreciation of life circumstances, and gratitude toward persons (thanking someone) by writing, contemplating, and reflecting (eg, with a gratitude partner) or expressing gratitude directly to another person
Savoring (50%)	Taking delight and replaying life's momentary pleasures and wonders. For example, by being open to beauty and excellence, through relishing ordinary experiences, and savoring those experiences with others
Flow (48%)	Increasing the number of challenging and absorbing (ie, "flow") experiences
Taking care of the body (39%)	Engaging in physical activity or exercise, being mindful with the body, smiling, and laughing
Spirituality (35%)	Becoming more involved in religion or spirituality by, for example, seeking meaning and purpose, finding the sacred in ordinary life, and being mindful
Relationships (33%)*	Strengthening and enjoying relationships by making time for people, expressing admiration, appreciation, and affection, capitalizing on good fortunes, being supportive and loyal, managing conflict, and sharing your inner life
Goals (28%)	Picking 1, 2, or 3 significant goals that are meaningful and devoting time and effort to pursuing them
Optimism (24%)*	Writing about best possible future selves, goals and subgoals, as well as identifying barriers and automatic pessimistic thoughts and coming up with ideas to minimize their effects
Forgiveness (7%)	Writing about letting go of anger and resentment toward other persons

These are listed from the most to the least frequently assigned exercises (in %).
*Four exercises chosen for the standardized treatment.

that the exercises were specifically tailored to match their preferences on the basis of their responses to the PAFD.

Participants assigned to the control group were instructed to be more attentive to their surroundings and write about 3 specific events or activities from the past 7 days for at least 15 minutes once a week for 8 weeks. This condition was designed to control for the effects of time and participation in an intervention activity.

All participants were prompted once a week by a standardized email sent by the first author using a tracking system (MS Access database). In this email, only participants in the intervention group were asked to complete online questions on how many days and for how long they practiced which exercise(s). If the participants had any questions about the exercises, questionnaires, or study procedures, they were invited to contact the first author at any time during the study by phone or email.

Measures

Participant Descriptor Measures

Descriptive measures including age, sex, ethnicity, education, employment, relationship status, disability type (including date of injury or first diagnosis of the disability), and pain type were assessed at baseline. Pain type (ie, "nociceptive," "unclear," and "neuropathic") was determined using 9 items of the painDETECT questionnaire (PD-Q).[62] One item asks respondents to indicate the type of pain on the basis of 4 different pain images that reflect different courses of pain (persistent pain with slight fluctuations, persistent pain with pain attacks, pain attacks without pain between them, pain attacks with pain between them). The other items ask respondents to rate the severity of 8 pain qualities (eg, "burning," "tingling," "numbness") on a 6-point scale ("Never" to "Very strongly"). Respondents are then classified as having 1 of 3 pain types on the basis of their total score. The PD-Q has support for its validity as a reliable screening tool with high sensitivity (85%), specificity (80%), and positive predictive accuracy (83%).[62]

Efficacy Measures

At baseline, immediately posttreatment, and 2.5 months after treatment, participants were asked to complete measures of the study outcome domains (described below) online by a secure server. Because this was a feasibility study, a primary outcome was not specified as we did not know what domains, if any, would be most strongly impacted by the intervention. Thus, our a priori criteria to conclude that the intervention was effective for any outcome domains included both (1) a statistically significant ($P < 0.05$) pretreatment to posttreatment time effect and (2) pretreatment to posttreatment effect sizes that were at least small (Cohen $d > 0.20$).[63] Measures of domains that showed at least a small treatment effect were to be considered feasible to assess the effects of the intervention in a larger trial. Selection of outcome measures was made on the basis of the following criteria: (1) measures found to be sensitive to the effects of positive psychology interventions (ie, subjective well-being and depression) and (2) measures that are known to be related to patients' experience of and beliefs about pain.

Life satisfaction: The 8-item Personal Wellbeing Index—Adult version (PWI-A)[64] assesses satisfaction with specific life domains (eg, health, achievement, relationships, future security) and overall life satisfaction. Responses are provided on a 0 to 10 NRS with endpoints "Completely dissatisfied" to "Completely satisfied." Higher scores refer to higher life satisfaction. The PWI has evidence supporting its reliability and validity as a measure of life satisfaction.[65,66]

Positive and negative affect: The 20-item Positive and Negative Affect Schedule (PANAS)[67] measures positive affect (eg, "enthusiastic") and negative affect (eg, "distressed") on a 5-point Likert scale ("Very slightly or not at all" to "Extremely"). Respondents rate the extent to which they have experienced each affect descriptor during the past week. Higher scores mean higher positive and negative affect, respectively. The PANAS is a commonly used measure of positive and negative affect (and its ratio), and has a great deal of evidence supporting its validity and reliability,[68,69] including in a rehabilitation population.[70]

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Depression: The 7-item depression subscale of the Hospital Anxiety and Depression Scale (HADS-D)[71] focuses on affective and cognitive rather than somatic aspects and is specifically developed for use among patients with somatic symptoms. Patients are asked to rate the severity of each symptom (during the past week) on a 0 to 3 scale. Higher scores indicate a higher depression level. The HADS has been found to be reliable and valid for assessing the severity of depressive symptoms in a disability population.[72]

Pain severity: The 0 to 10 NRS was used to assess the average pain intensity in the past week. NRS is recommended as a core outcome measure of pain intensity in clinical trials of pain treatments.[73]

Pain interference: An adapted 12-item version of the Pain Interference Scale[74] from the Brief Pain Inventory[75] was used to measure pain interference. It asks respondents to rate on 10-point NRS (endpoints, "Does not interfere" and "Completely interferes") the extent to which their pain interferes with different daily activities (eg, work, sleep, mood). Higher scores indicate higher pain interference. This measure has been found to be reliable and valid as a measure of pain interference in individuals with a disability.[74]

Pain control: The 10-item Control scale of the Survey of Pain Attitudes (SOPA)[76] assesses the extent to which the respondent believes that he or she can control pain when it occurs. Respondents rate each statement reflecting control over pain on a 5-point scale ("This is very untrue for me" to "This is very true for me"). Higher scores refer to higher control over pain. The reliability and validity of the SOPA has been confirmed in a number of studies that included individuals with physical disabilities.[76–78]

Pain acceptance: The 8-item Chronic Pain Acceptance Questionnaire—Short version (CPAQ-8)[79] asks to rate how true statements reflecting activity engagement and willingness to experience pain are for respondents using a 0 to 6 Likert scale ("Never true" to "Always true"). Higher scores indicate better acceptance of pain. The reliability and validity of the CPAQ-8 has been confirmed in a mixed chronic pain population.[79]

Pain catastrophizing: The 13-item Pain Catastrophizing Scale (PCS)[80] assesses 3 domains of pain-related catastrophizing (rumination, helplessness, and magnification) using a 0 to 4 rating scale ("Not at all" to "All the time"). Higher scores indicate higher pain catastrophizing. The PCS is commonly used and has been found to be a reliable and valid measure in individuals with different pain disorders.[81–83]

Feasibility and Acceptability/Treatment Satisfaction Measures

A priori criteria for success of feasibility included all of the following: a response rate to the study approach letter of $\geq 25\%$, a recruitment rate of $\geq 80\%$ of eligible individuals, and an attrition rate at posttreatment of $\leq 20\%$ and at follow-up another $\leq 15\%$. We anticipated that at least 75% of the participants would respond to 6 of the 8 weekly reminder questionnaires. We also predicted that participants would take about 20 to 30 minutes to complete each questionnaire at baseline, posttreatment, and follow-up.

Acceptability of the intervention was assessed posttreatment using a treatment satisfaction questionnaire. Participants in both groups were asked to indicate (1) how much they benefitted from the intervention on a 5-point Likert scale ("No benefit" to "Extreme benefit"), (2) how much they experienced negative effects related to the intervention on a 5-point Likert scale ("No negative effects" to "Extreme negative effects"), and (3) how satisfied or dissatisfied they were by the intervention on a 7-point Likert scale ("Very satisfied" to "Very dissatisfied"). In addition, participants were invited to provide free-text comments on the overall benefit, negative effects, and satisfaction of the intervention. We determined a priori that the intervention would be considered acceptable if the average benefit rating indicated at least "Some benefit," the average satisfaction rating indicated that the participants were at least "Somewhat satisfied," and if no significant negative effects were reported.

We examined the "dose" received of the positive psychology intervention by asking participants to indicate on the weekly online questionnaire the number of days they practiced the exercises (1 = 1 d/wk, 2 = > 1 d/wk, 3 = > 1 d/wk and also on bad days, 4 = I have not done it), and for how long they practiced the exercises on those days (1 = 15 min, 2 = > 15 min, 3 = I have not done it). Analyses included a comparison of groups on the well-being and pain-related outcomes as a function of the number of times the exercises were practiced and for how long. We anticipated significantly better effects on the outcome measures for those participants who practiced the exercises for longer than 15 minutes for >1 day every week compared with those who practiced for shorter periods of time or less often.

Data Analyses

We first computed descriptive analyses in SPSS version 19.0[84] to describe the study sample. As a next step, to determine the feasibility of the study design and procedures, we completed a participant flow chart as recommended by CONSORT[85] and computed feasibility measures, described above. In addition, we calculated the mean time necessary to complete baseline, PAFD, posttreatment, and follow-up questionnaires. Respondents' comments on the content of the questionnaires were evaluated.

Next, to determine the acceptability of the intervention, we calculated the mean rates of benefit, negative effect, and satisfaction of the intervention. Comments on benefit and satisfaction of the intervention from participants in the intervention group were examined, grouped on the basis of their content, and linked to different study outcomes.

To determine the effects of the intervention on the study outcome measures, we first tested for a Time × Treatment Condition interaction using the pretreatment and posttreatment data. We also carried out analyses to test for pretreatment to posttreatment changes in outcome for each of the treatment conditions. We then repeated these analyses using data obtained at pretreatment and follow-up. For each outcome, we computed pretreatment to posttreatment effect sizes (Cohen d). To determine the sample size to detect significant effects of the intervention in a larger efficacy trial, we computed the sample size that would be needed to have adequate power (0.80) to detect a significant effect, given the between-group effect sizes associated with a pretreatment to posttreatment improvement in pain intensity and assuming an α of 0.05. In addition, we calculated the number needed to treat (NNT) for pain intensity (ie, the number of individuals who need to be treated for one to benefit compared with the control group). We based NNT analysis on a reduction of pain intensity of 2 points between pretreatment and posttreatment assessment on the 0 to 10 NRS.

To evaluate the intervention dose that participants provided for themselves and the associations between dose and outcome, we classified participants into groups representing the number of days they practiced the exercises (1 d/wk, >1 d/wk, >1 d/wk plus on "bad" days), and the duration or practice time (15 min, >15 min) by computing the average of the ratings for each of these dose domains. We then compared pretreatment to posttreatment Cohen *d* effect size of each outcome between the different dose groups. Finally, to evaluate the utility of each outcome measure to detect treatment effects with the study intervention, we examined the pretreatment to posttreatment Cohen *d* effect size values associated with each outcome measure.

RESULTS

Sample Description

As can be seen in Table 2, 70% of the participants were women. Participants were mostly non-Hispanic white (96%), mean age 59.4 years. Twenty-five percent reported

TABLE 2. Descriptive Characteristics of the Study Participants

	n (%)		
	Intervention Group (n = 51)	**Control Group (n = 45)**	**Total (N = 96)**
Age			
Mean (SD) (range) (y)	58.9 (11.9) (24-81)	59.9 (11.73) (34-79)	59.4 (11.78) (24-81)
Missing	0	2	2
Sex			
Male	17 (33.3)	12 (26.7)	29 (30.2)
Female	34 (66.7)	33 (73.3)	67 (69.8)
Ethnicity			
White	50 (98.0)	42 (93.3)	92 (95.8)
American Indian/Alaska Native	0 (0)	2 (4.4)	2 (2.1)
Asian	0 (0)	0 (0)	0 (0)
Black/African American	0 (0)	0 (0)	0 (0)
Native Hawaiian/other Pacific Islander	0 (0)	0 (0)	0 (0)
Hispanic/Latino	2 (2.0)	0 (0)	2 (2.1)
Other	0 (0)	2 (4.4)	2 (2.1)
Education			
Mean (SD) (range) (y)	5.7 (1.1) (3-7)	5.9 (1.07) (4-7)	5.8 (1.1) (3-7)
Missing	0	0	0
Employment			
Full-time	6 (11.8)	2 (4.4)	8 (8.3)
Part-time	3 (5.9)	6 (13.3)	9 (9.4)
Attending school/vocational training full-time	0 (0)	0 (0)	0 (0)
Attending school/vocational training part-time	0 (0)	0 (0)	0 (0)
Retired	22 (43.1)	23 (51.1)	45 (46.9)
Homemaker	3 (5.9)	1 (2.2)	4 (4.2)
Unemployed due to pain	3 (5.9)	2 (4.4)	5 (5.2)
Unemployed due to disability	22 (43.1)	13 (28.9)	35 (36.5)
Unemployed for other reasons	4 (7.8)	2 (4.4)	6 (6.3)
Relationship status			
In a relationship	37 (72.5)	30 (66.7)	67 (69.8)
Single	14 (27.5)	15 (33.3)	29 (30.2)
Disability			
SCI	13 (25.5)	11 (24.4)	24 (25.0)
MS	14 (27.5)	12 (26.7)	26 (27.1)
NMD	14 (27.5)	14 (31.1)	28 (29.2)
PPS	18 (35.5)	16 (35.6)	34 (35.4)
Pain intensity			
Mean (SD)	6.65 (1.61)	6.69 (1.49)	6.67 (1.55)
Missing	0	0	0
Pain type			
Nociceptive pain*	24 (47.1)	20 (44.4)	44 (45.8)
Neuropathic pain†	13 (25.5)	11 (24.4)	24 (25.0)
Unclear‡	13 (25.5)	14 (31.1)	27 (28.1)
Missing	1	0	1

*A neuropathic pain component is unlikely (< 15%).
†Results of the painDETECT are ambiguous; however, a neuropathic pain component can be present.
‡A neuropathic pain component is likely (> 90%).
MS indicates multiple sclerosis; NMD, neuromuscular disease; PPS, postpolio syndrome; SCI, spinal cord injury.

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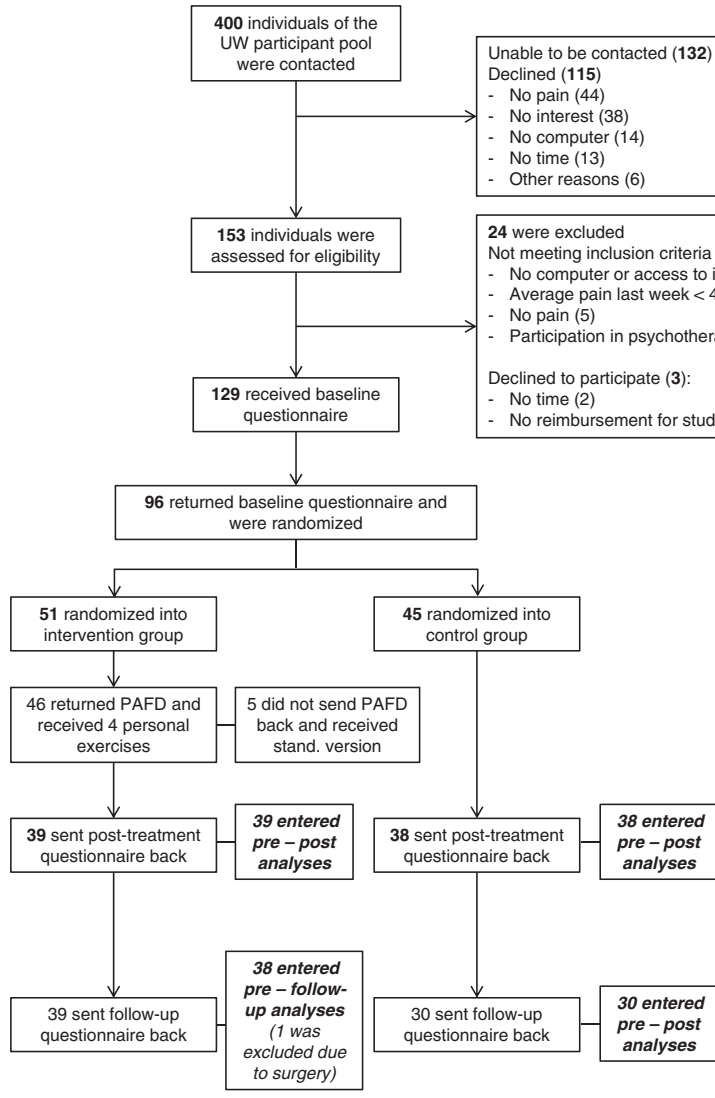

FIGURE 1. Participants' flow.

being diagnosed with SCI, 27% with MS, 29% with NMD, and 35% with PPS. Probable neuropathic pain was reported by 25% of the participants; 46% reported having probably nociceptive pain problems and in 28% of participants, pain type was unclear.

Feasibility of the Study

As shown in Figure 1 and with respect to the first aim of this study, the response rate to the study approach letter was 38%. With 129 participants who were eligible to participate and provided consent, the recruitment rate was 84%. The highest exclusion rate was found in the criterion of not having a computer or access to the Internet (5%). Ninety-six of the participants who consented returned the baseline questionnaire (completion rate: 74%) and were randomized into the intervention or the control group. Five of the participants in the intervention group did not complete the PAFD (completion rate: 90%) and received the standardized version of the exercises. A total of 77 participants completed the posttreatment questionnaire (attrition rate: 20%). A total of 68 participants completed the follow-up questionnaire (attrition rate: 10%). In addition, the time necessary to complete the questionnaires (baseline, post, and follow-up) was found to be in the expected range (20 to 30 min for each questionnaire), and no negative feedback for the content of the questionnaires was reported by the participants. However, some participants reported having difficulties understanding the response options of the PAFD.

Acceptability of the Intervention

With respect to the second study aim, Kindness (83%), Gratitude (54%), Savoring (50%), and Flow (48%) were the most often assigned exercises on the basis of the PAFD scores (Table 1). Figure 2 shows the frequencies of each satisfaction and benefit category. The mean rating on how much participants benefitted was between "Some benefit" and "A lot of benefit" (mean = 3.56, SD = 1.02) for the intervention group, and between "A little benefit" and "Some benefit" (mean = 2.81, SD = 1.06) for the control group. The average treatment satisfaction ratings were near "Somewhat satisfied" for both groups (intervention group: mean = 2.13, SD = 1.59/control group: mean = 2.56,

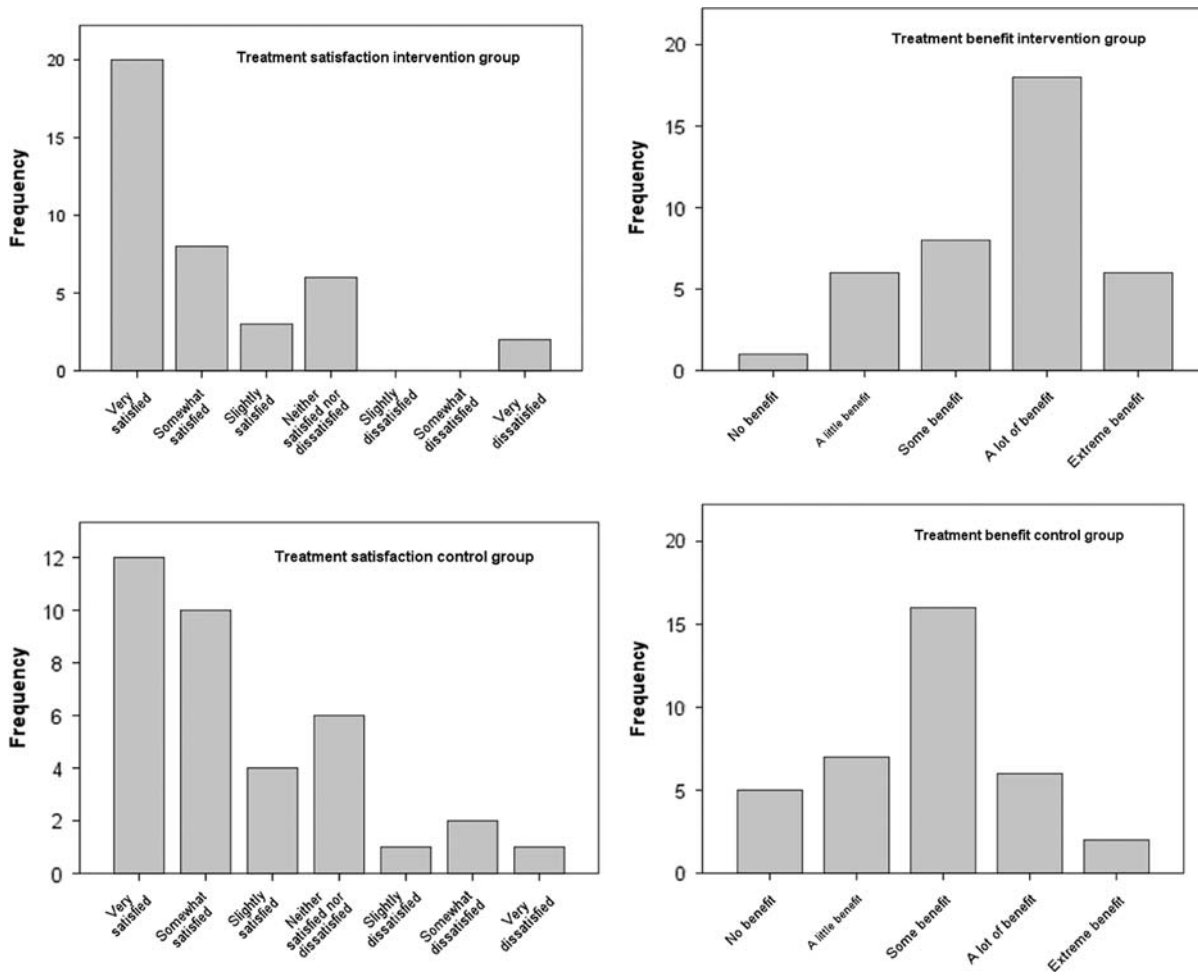

FIGURE 2. Frequencies of the satisfaction and benefit categories.

TABLE 3. Some Grouped Examples of the Participants' Written Feedback on the Positive Psychology Intervention

Topic	Feedback
Life satisfaction	"I was able to reflect on all the positive things, accomplishments and relationships in my life making me realize in the grand scheme of things I am very fortunate. I still get frustrated at times but have changed my approach on dealing with that feeling."
	"I feel closer with my wife for she 'gets it' even more now of how I feel and think daily in my chronic place."
Positive affect	"It made me feel like a better person."
	"It gave something positive for me to look forward to, a reason to get home and work on something other than how I feel."
	"…it felt good to help others so that lessened my pain and thoughts about myself."
Depression	"The study has helped give incentives to go and exercise and socialize, where prior I may have blown it off, much like I did during phases of depression."
	"Empathy towards others… [It] takes more energy to be down and depressed… might as well learn to express positiveness. This positive attitude draws others toward you."
Pain interference and control	"While I was busy concentrating on other things [flow] I could forget about my pain."
	"Pain has no longer control!"
	"I am able to change my thought process by meditation or savoring so I am not dwelling on my pain."
Intervention	"Exercises were short and as a result, I felt motivated to do longer sessions than required."
	"They were activities that brought me and others joy, were sometimes fun and made me feel happier. The structure of being asked to do these [exercises] motivated me to do something."
	"I felt satisfied in the manner that the exercises condone my lifestyle."
	"Satisfaction came from being guided by the assignments and the positive energy I gained by practicing them regularly. I will continue to do so because I like where they put me mentally."

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TABLE 4. Pretreatment to Posttreatment Comparison for Participants in Intervention Group (n = 39) and Control Group (n = 38) and Pretreatment to Follow-up Comparison for Participants in the Intervention Group (n = 38) and Control Group (n = 30)

	Treatment Condition	Pretreatment (Mean/SD)	Posttreatment (Mean/SD)	Posttreatment Effect size†	Time Effect Posttreatment (*F* (*df*))	Time× Treatment Condition Posttreatment (*F* (*df*))	2.5 mo Follow-up (Mean/SD)	Time Effect Follow-up (*F* (*df*))	Time× Treatment Condition Follow-up (*F* (*df*))
Life satisfaction	Intervention	65.21 (18.82)	70.15 (17.28)	0.27	**5.29 (1,38)***	0.12 (1,75)	69.47 (18.72)	**5.08 (1,37)***	2.11 (1,66)
	Control	71.89 (11.74)	76.00 (11.16)	0.36	**11.32 (1,37)****		72.16 (15.13)	0.13 (1,29)	
Positive affect	Intervention	31.46 (6.90)	34.00 (7.26)	0.36	**4.50 (1,38)***	2.69 (1,75)	31.81 (6.78)	0.21 (1,37)	0.81 (1,66)
	Control	35.42 (6.76)	35.50 (7.09)	0.01	0.01 (1,37)		34.47 (6.60)	0.93 (1,29)	
Negative affect	Intervention	17.38 (6.61)	16.56 (7.57)	0.16	0.63 (1,38)	1.22 (1,75)	15.86 (6.87)	1.84 (1,37)	0.40 (1,66)
	Control	16.58 (5.83)	17.50 (6.95)	0.14	0.60 (1,37)		16.37 (5.44)	0.39 (1,29)	
Depression	Intervention	5.78 (3.23)	4.44 (3.54)	0.40	**9.18 (1,35)****	1.36 (1,71)	4.91 (3.74)	**4.27 (1,34)***	0.41 (1,66)
	Control	4.97 (2.77)	4.32 (2.94)	0.23	2.77 (1,36)		4.38 (3.00)	2.04 (1,28)	
Pain intensity	Intervention	6.56 (1.58)	5.38 (2.02)	0.65	**16.66 (1,38)****	**5.17 (1,75)***	5.97 (2.02)	**4.39 (1,37)***	0.02 (1,66)
	Control	6.66 (1.46)	6.45 (1.96)	0.12	0.45 (1,37)		6.00 (1.89)	**4.52 (1.29)***	
Pain interference	Intervention	67.10 (25.71)	52.72 (25.78)	0.56	**13.01 (1,38)****	1.10 (1,75)	55.13 (28.36)	**10.30 (1,37)****	2.73 (1,66)
	Control	68.08 (24.57)	59.94 (27.14)	0.31	3.33 (1,37)		59.70 (29.14)	0.50 (1,29)	
Pain control	Intervention	27.59 (7.13)	32.62(9.21)	0.61	**13.63 (1,38)****	**4.31 (1,75)***	32.79 (8.80)	**11.85 (1,37)****	2.31 (1,66)
	Control	30.39 (7.84)	31.89 (9.28)	0.17	2.24 (1,37)		33.20 (9.13)	**5.02 (1,29)***	
Pain acceptance	Intervention	36.10 (7.24)	36.74 (7.10)	0.09	0.43 (1,38)	0.51 (1,75)	35.81 (8.08)	0.01 (1,37)	0.18 (1,66)
	Control	35.84 (7.26)	37.39 (7.13)	0.21	3.73 (1,37)		36.87 (7.96)	0.37 (1,29)	
Pain catastrophizing	Intervention	23.51 (7.81)	21.41 (7.76)	0.27	**6.76 (1,38)****	0.71 (1,75)	22.24 (9.10)	1.29 (1,37)	0.22 (1,66)
	Control	24.61 (7.94)	23.39 (7.16)	0.10	0.31 (1,37)		23.10 (8.18)	0.33 (1,29)	

Bold values are statistically significant.
*$P \leq 0.05$.
**$P \leq 0.01$.
†Cohen *d* effect size.

SD = 1.65). Some grouped examples of comments are listed in Table 3. A few minor negative effects were reported across both groups, such as "Occasional numbness in hands during journaling" (control group), "Adding to the list of things I had to do" (control group), or "Feelings of discouragement that come and go" (intervention group). One participant in the control group reported becoming "very sad" on writing about specific events or activities. This individual was instructed to stop practicing the exercise, given this adverse event, was withdrawn from the study, and was offered help from one of the study psychologists.

Effects of the Interventions

No significant differences between groups were found at baseline for any of the outcome measures, except for positive affect ($F_{1,77} = 6.46$, $P = 0.013$). Table 4 presents the means and SDs of the outcome measures at each assessment point. Results of ANOVA indicated that the positive psychology intervention resulted in an immediate (ie, posttreatment) and statistically significant increase in life satisfaction, positive affect, and pain control, and a significant reduction in depressive symptoms, pain intensity, pain interference, and pain catastrophizing. In the control group, only a significant increase in life satisfaction was found at posttreatment. The pretreatment to posttreatment Time × Treatment Condition interactions were statistically significant for pain intensity and perceived control over pain, indicating that the positive psychology intervention was superior to the control group in reducing pain intensity and enhancing pain control. Nonsignificant pretreatment to follow-up Time × Treatment Condition interactions were found at follow-up. Improvements in life

satisfaction, depressive symptoms, pain intensity, pain interference, and pain control were maintained at the 2.5-month follow-up assessment for the intervention group. In the control group, pain intensity and pain control improved significantly after 2.5 months, relative to the baseline levels.

Given the between-group effect sizes (Cohen $d = 0.52$ for the pretreatment to posttreatment improvement in pain intensity), power analyses indicated that a total sample of 118 participants (59 per treatment condition) would provide an 80% power to reject the null hypothesis with an α-level of 0.05 for this outcome. Analyses showed an NNT of 6.7 for the positive psychology treatment in comparison with the control treatment.

Dose Received and Dose Effects

The majority (86%) of the participants in the intervention group responded to at least 6 of the total 8 weekly reminder questionnaires during the treatment phase and indicated that they practiced their exercises. Almost half the participants in the intervention group (45%) reported that they practiced the exercises >1 day every week. A little less than a third of the participants (29%) practiced the exercise >1 day per week, including on "bad" days. The rest (26%) practiced the exercises about 1 day every week. We observed greater pretreatment to posttreatment Cohen d effect sizes in pain control ($d = 1.24$), pain intensity ($d = 1.11$), pain catastrophizing ($d = 0.86$), pain interference ($d = 0.46$), and positive affect ($d = 0.38$) in the subgroup that reported that they practiced the exercises the most (> 1 d/wk plus on "bad" days) relative to the other 2 dose subgroups. With respect to depressive symptoms ($d = 1.20$) and life satisfaction ($d = 0.36$), the subgroup that reported having practiced the exercises >1 day/week (but *not* on "bad" days) showed larger effect sizes than the other 2 subgroups. However, the sample sizes available for the subgroup comparisons were small, limiting our power to detect statistically significant differences.

The majority of the participants (84%) reported that they practiced the exercises longer than 15 minutes. We observed greater pretreatment to posttreatment improvements in pain intensity ($d = 0.87$), pain interference ($d = 0.54$), pain control ($d = 0.36$), positive affect ($d = 0.29$), and life satisfaction ($d = 0.21$) in the group that reported that they performed the exercises longer than 15 minutes, but greater improvements in depressive symptoms ($d = 0.65$) and pain catastrophizing ($d = 0.33$) in the group that reported that they practiced the exercises only 15 minutes. However, the sample sizes available for the subgroup comparisons were again small.

Utility of the Outcome Measures for Detecting at Least a Moderate Effect

Table 4 presents the effect sizes associated with pretreatment to posttreatment differences for all of the outcome variables. We found at least small effects (Cohen $d \geq 0.20$) for all outcome measures, except for the one measuring pain acceptance ($d = 0.09$) and negative affect ($d = 0.16$).

DISCUSSION

The purpose of this study was to determine the feasibility, acceptability, and efficacy of a computer-based tailored positive psychology intervention designed to enhance well-being and reduce chronic pain in individuals with a physical disability. The response and attrition rates fulfilled our a priori conditions for concluding that the study was feasible. The study design and procedures were successful in enrolling, engaging, and maintaining participants in the trial, and suggest that similar procedures would be reasonable for a future full clinical trial. The attrition rate in the present study was close to what is recommended in the literature as necessary for study validity in general (20%),[86] was similar to Internet-based cognitive-behavioral therapy interventions for chronic pain (27%),[87] and lower than the dropout rates in Internet-based interventions for anxiety and depression disorders (up to 50%).[55] Nonetheless, given that we recruited participants from a registry of individuals who were willing to participate in research, lower response and higher attrition rates might be anticipated in community samples.

We also found that the positive psychology exercises and the control exercise were acceptable to the study participants. Although the reported adverse events associated with the interventions (eg, numbness in the hands during journaling, feelings of discouragement and sadness) might be expected for some participants with these interventions, it is important to be aware of these potential negative effects to mitigate them in future trials (eg, by providing resource lists of psychological and medical support for those participants who could benefit from these).

With respect to the effects of the positive psychology intervention studied here, the results are promising; they suggest that a relatively low-intensity Web-based positive psychology intervention with minimal therapist contact may have real benefits in terms of not only reducing pain but also in improving overall well-being. The results also indicate that a full-size randomized trial is warranted. We found a mean pretreatment to posttreatment effect size of $d = 0.30$ on well-being, which is comparable with the effects of cognitive behavioral therapy on psychosocial health in individuals with a physical disability.[23,24] We also found a mean pretreatment to posttreatment effect size of $d = 0.44$ for pain-related outcomes, which can be compared with other nonpharmacological treatments such as electric or magnetic stimulation, physical exercise, acupuncture, and self-hypnosis in individuals with physical disabilities.[88]

Although benefits were found for the majority of outcome domains assessed, no beneficial effect of the positive psychology intervention was found on measures of pain acceptance and negative affect. These findings might have a number of possible explanations. First, the intervention may simply not be effective in enhancing pain acceptance and reducing negative affect. It is also possible that the measures chosen to assess these domains are not sensitive enough to detect the effects of the intervention in a relatively small sample.

In addition, no longer lasting beneficial effects of the positive psychology intervention were found on the measures of positive affect and pain catastrophizing. Although positive psychology interventions are known to immediately boost positive affect,[36] it seems necessary for individuals to continue practicing these exercises to maintain improvements.[35] In the present study, 26% of study participants indicated that they did not continue practicing the positive psychology exercises. Given that pain catastrophizing has been conceptualized and measured not only as a state-dependent, situation-specific construct but also as a trait-like, rather stable concept, the positive psychology intervention may not have been effective (enough) in lowering pain catastrophizing in the long term.[89] Therapist-delivered cognitive-behavioral therapy and/or guided in vivo exposure treatment carried out in tandem with positive psychology exercises (eg, mindfulness meditation,

Acceptance and Commitment Therapy) might be more effective in sustainably reducing pain catastrophizing.[90]

It is important to mention that the control group also seemed to benefit from the intervention, given that they reported increases in life satisfaction from pretreatment to posttreatment. Participants in the control group were instructed to be more attentive and to "choose an event or activity during your leisure time, your work or simply doing household chores, it does not need to be something particularly special" and "remember and write down as many details as possible." On the basis of the feedback that we received from the control group participants, a fair number of them indicated that they were writing about *positive* activities and events during the 8-week control intervention. Thus, although it is possible that the increase in life satisfaction reported by the control group was only or primarily because of time effects (ie, regression to the mean), it is also possible that some of the improvements in life satisfaction may have been because of an increased focus on positive activities. Some support for this possibility comes from research that has shown comparable findings indicating that writing about positive experiences enhances positive mood and health.[91]

On the basis of the effect sizes found, a power analysis indicated that a total sample size of 118 participants (59 per treatment condition) would be adequate to detect significant effects of the positive psychology intervention on a primary outcome measure of average pain intensity in a larger efficacy trail. Therefore, it seems to be reasonable to plan to enroll at least 160 participants (35% more than needed to take into account possible attrition) in a future trial.

With respect to intervention dose, participants who practiced their exercises >1 day a week for longer than 15 minutes seem to have benefited more from the intervention than participants who practiced the exercises less frequently. Therefore, to maximize the benefits of the treatment, a modified version of the instructions for a future efficacy trial could include recommendations, such as "Please do the following exercise *at least* one day a week for at least 15 minutes. You are free to do the exercise more often than this, as well as on 'difficult or bad' days […]. In fact, based on findings of previous studies we recommend you practice the exercise for longer than 15 minutes and on more than one day a week when possible." However, given that the amount of practice to address adherence to treatment was based on self-report and not independently verified, it is possible that some participants may have underreported or overreported actual practice. This is one possible explanation for the discrepancies found in the relationship on usage and treatment benefit.

With respect to our aim to identify appropriate outcome measures for a full-size trial, the findings indicate that all outcome measures except for those assessing acceptance and negative affect would be appropriate and feasible as measures to assess the effects of the positive psychology intervention. A recent systematic review of the psychometric properties of questionnaires that aim to measure acceptance of chronic pain showed that, out of 4 measures evaluated, none fulfilled all criteria for adequate psychometric quality.[92] However, in this review, the CPAQ-8, which was used in the current study, was ranked as having the best psychometric qualities of the available measures. As we have discussed, our negative findings with respect to pain acceptance may have been because either (1) the positive psychology intervention was not effective in enhancing pain acceptance or (2) the CPAQ-8 may not be adequately sensitive to detect treatment effects. On the basis of our findings, including the CPAQ-8 or other measures of pain acceptance might add unnecessary assessment burden to a positive psychology trial; the field may need to wait until measures with better psychometric qualities are developed before we can evaluate the effects of positive psychology interventions on this domain.

Treatment adherence is a crucial determinant of the treatment outcome and can be affected by, for example, the complexity of treatment content and instructions, unpleasant side effects, absence of immediate positive effect, and characteristics of the individual (eg, illness belief, motivation, expectations, attitude).[93,94] In the current study, we monitored adherence to the treatment by sending weekly emails to all participants and encouraged them to keep on practicing the exercises. We also asked individuals in the intervention group to report on the frequency and duration of practicing the exercises. Adherence may have been improved by tailoring the exercises to the participants' activity interest and by the fact that the exercises are brief, simple, and self-administered positive activities that are easy to perform, require little time, have no financial cost, have more pleasant than negative side effects, and are known to have immediate benefits on positive affect. Adherence could potentially also be improved by increased computer-based dialog support (eg, more therapist interaction by email or forum) or persuasive technologies (eg, smart phone reminder app). Furthermore, in clinical practice, adherence could also potentially be increased by incorporating positive psychology exercises into interdisciplinary treatment strategies as these exercises can be easily disseminated and quickly used by clinicians and treatment providers.

Limitations

The current study has several important limitations that should be taken into account when considering the findings and implications of this study for future research. First, the positive psychology intervention evaluated here was a tailored intervention comprised of a combination of specific positive psychology strategies rather than one specific intervention protocol. Tailoring the positive psychology exercises to each individual's styles/preferences is a strength of the study, given the need for research on tailored approaches to pain management.[27] However, our design does not allow for an evaluation of specific beneficial effects of tailoring versus not tailoring the intervention. Similarly, the study design does not allow for an evaluation of the relative value of the different exercises; it is possible, if not likely, that some exercises may be more beneficial than others. Elucidating the putative mechanisms underlying the treatment effects is an important step for future research in addition to testing overall efficacy. Second, we did not monitor for pain treatment during the study, which could potentially have influenced the effects of the positive psychology exercises. To ensure similar levels of medical services utilization and pain treatment between groups in a future trial, participants should be asked to report any professional care for pain and medication use at each assessment point. This information can then be coded and controlled for in data analyses.

CONCLUSIONS

The results of this pilot study support the feasibility, acceptability, and potential efficacy of a computer-based

positive psychology intervention for improving well-being and pain-related outcomes in individuals with physical disabilities and chronic pain. The findings indicate that a full-size trial of the intervention is warranted.

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