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A digital values-based microintervention for chronic back pain patients: lessons learned from a randomised experimental single-case study

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Abstract

Background Chronic pain usually lasts several years. During this time, value-oriented aspects of life often fade into the background in favour of coping with the pain, which is associated with a lower quality of life. Psychotherapeutic methods such as Acceptance and Commitment Therapy can alleviate this. However, for those who suffer from chronic pain, access to such therapies is limited. Electronic health interventions provide access to evidence-based methods. The aim of this study was to investigate the effectiveness and feasibility of a brief electronic values-based intervention on patients with chronic back pain.

Methods A study with a replicated AB single-case experimental design was conducted with 28 participants suffering from chronic back pain. Participants answered daily questions concerning their pain intensity and quality of life (well-being, pain catastrophising, acceptance of chronic pain, engaged living) for 10 to 17 days. The subsequent mobile intervention on value-oriented activities lasted an additional 10 days. During this time, daily assessments continued. Our analysis was performed using a hierarchical two-level modelling approach as well as visual and descriptive analysis.

Results The majority of participants did not measurably benefit from the intervention. Neither model-based inference nor visual analysis indicated plausible intervention effects. The results of one responder and one non-responder are presented. In their qualitative feedback, most participants described being satisfied with the intervention. The perceived usefulness of psychotherapy as a treatment for chronic back pain increased from pre- to post-intervention ($p < .001$, $d_z = 1.17$).

Conclusions This study shows that microinterventions for chronic back pain patients are feasible, but should be planned over a longer period of time to enable measurable changes. The electronic mobile format did not cause participants any difficulties.

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Introduction

People suffering from chronic pain usually suffer from it for several years [1]. During that time, the attempt to cope with the pain often becomes their main life focus, meaning that values and goals in other aspects of life can recede into the background [2]. Deficient values-based goals and actions are related to a decline in quality of life [3]. The compromising of personally meaningful values and goals of chronic pain patients [4] is attributable to an unending cycle of weighing pain avoidance against the costs associated with the loss of these activities [5]. Since chronic pain is associated with physical disabilities, adjusting one's goals to one's own functional abilities is an important treatment component when specific goals become unattainable [6]. A central element is therefore to reduce the effort required to achieve unattainable goals while simultaneously identifying and pursuing new, values-based and attainable goals [7].

In this regard, accepting one's own chronic pain and related functional limitations as well as pursuing values-oriented activities are two essential processes. Acceptance refers to the willingness to accept unpleasant emotions and perceptions without succumbing to the tendency to control them. Values-based action involves aligning one's actions with personally meaningful purposes [8].

Both acceptance and values-based actions are important elements of Acceptance and Commitment Therapy (ACT) [8]. ACT is an intensively-researched therapy method [9] that appears to be effective in treating chronic pain [10] with even very brief interventions having positive effects [11]. Low-threshold self-help interventions for patients also seem to help [12]. Despite these positive findings, the treatment of chronic pain remains a challenge—on the one hand, because effect sizes have stagnated for so long [13] and, on the other hand, because it is difficult for many patients, especially in rural areas, to even access therapy because of various barriers [14].

Electronic health interventions such as health apps can be helpful tools in overcoming these challenges [15]. Due to the widespread use of smartphones, pain apps have the potential to reach many users within a short period of time [16], thus enabling evidence-based interventions to disseminate quickly. Two recent meta-analyses demonstrate that health apps can have a positive impact on pain intensity and pain catastrophising [17]. However, it is not clear which elements of pain apps are accountable for the positive results.

Digital microinterventions provide a useful way of measuring the effectiveness of specific interventions that may be relevant for change. Microinterventions are brief, focused interventions that are easily incorporated within everyday life [18]. There is already research evidence on this topic: Microinterventions can, for instance, help regulate mood [19], increase body satisfaction [20] and promote prosocial behaviour [21]. Microinterventions may also have positive effects on people with chronic pain [22]. The aim of this study was to investigate the effectiveness and feasibility of a mobile microintervention on acceptance and values-based action for people with chronic back pain. To investigate this research question, we applied a single-case experimental design (SCED). SCEDs are study designs in which individuals are observed over a longer period of time with regard to at least one manipulated variable [23]. SCEDs are suitable for testing whether a microintervention is successful [24], and they can help in developing new interventions [25]. The microintervention was conducted on a daily basis over a period of ten days. We chose to use a SCED because it allows us to track potential changes on a daily basis. This enables us to assess whether a certain intervention content leads to a change in observed outcome variables.

Methods

Study design

This study used a replicated AB single-case experimental design with a randomised intervention starting point [26]. Baseline phase (A) varied between 10 and 17 days and served as a control per participant. The intervention phase (B) consisted of 10 daily measures (Fig. 1).

The study protocol followed the Declaration of Helsinki's tenets and was approved by the local ethics committee at the department of psychology of Philipps University of Marburg (2021-85v). The study was preregistered on ClinicalTrials.gov (ID: NCT05205889).

Participants and recruitment

Recruitment took place from February 2022 to April 2022. Participants were recruited through a mailing list consisting of pain patients who had already expressed interest in pain research. Recruitment was also facilitated by posts on social media and online forums. Inclusion criteria were: 1: minimum 18 years of age; 2: chronic back pain ($\geq$ 6 months); 3: pain intensity matching a minimum score of 4 on a 11-point numerical rating scale; 4: access

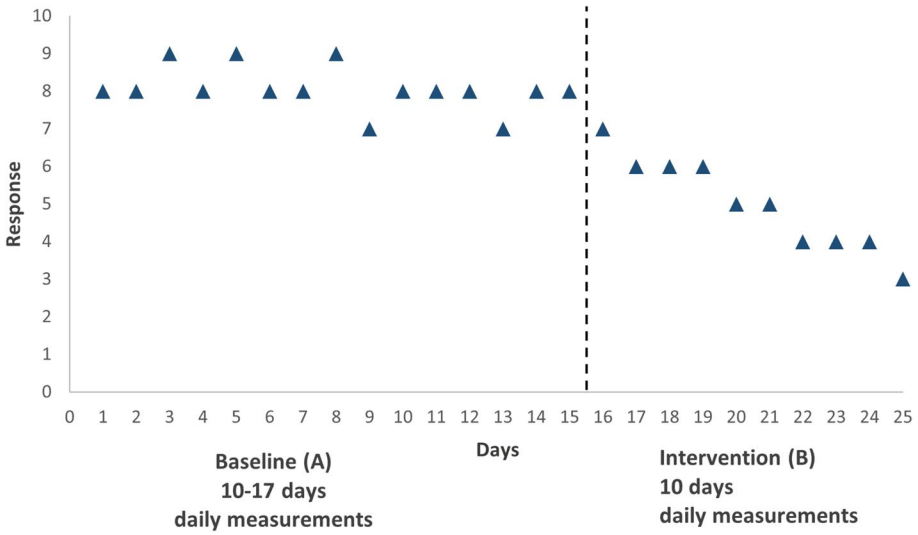

Fig. 1 Study design and assessments. It is hypothesised that the baseline phase will be stable and that during intervention phase, pain intensity and pain catastrophising will decrease whereas psychological wellbeing, pain acceptance and engaged living measures will increase. During baseline and intervention phase, daily measures are presented via 11-point Likert-type scales

to a smartphone or tablet. Participants were excluded if their back pain was tumour-related.

Since there appears to be no meaningful difference between patients suffering from pain for more than 3 months, compared to more than 6 months [27], we chose the inclusion criteria of longer duration, as did other recent studies [28]. Pain intensity ≥ 4 was chosen in order to include participants suffering from clinically relevant chronic back pain [29, 30]. As with the chosen pain duration criteria, we wanted to ensure that people with chronic back pain who were significantly impaired by their pain participated in our study. Figure 2 illustrates the enrolment course and drop-outs.

Intervention

The unguided, values-based and goal-focused intervention consisted of ten modules which included text, audio, and animated video files. The intervention was optimised to be completed digitally via smartphone or tablet. The overarching aim of the intervention was to support participants in developing values and values-based actions despite their pain. Each module took no longer than 15 min to complete. A detailed description of the intervention modules is found in Table 1.

Measures

All variables were assessed on a daily basis throughout each baseline and intervention phase via extracted items from established questionnaires. Additionally, daily measures were supplemented by taking pre- and post-measurements.

Pre-and post-measures

Pre-measurements were taken before each participants' individual baseline phase began, and post-measurements after completion of the final intervention module.

Pain intensity was assessed via a 11-point numerical rating scale (NRS). The endpoints of the scales ranged from "no pain at all" to "the worst imaginable pain". The NRS is a sensitive, valid, reliable, and easily administered scale, which is commonly used for pain assessment [31].

The 5-item World Health Organization Well-Being Index (WHO-5) [32] was used to capture psychological general wellbeing. The WHO-5 is an economical tool of adequate validity which assesses subjective wellbeing on a 6-point Likert scale [33]. The German version shows excellent reliability ($\alpha = 0.92$) [34]. Moreover, the WHO-5 is sensitive to change over time [33].

Pain catastrophising was assessed using the German version [35] of the Pain Catastrophizing Scale (PCS) [36]. The questionnaire assesses pain-related catastrophising thinking and behaviour through 13 items on a 5-point Likert scale. The German version of the PCS possesses excellent reliability ($\alpha = 0.92$) and adequate validity [35].

To assess chronic pain acceptance, we employed the 8-item version of the Chronic Pain Acceptance Questionnaire [37] (CPAQ-8), known for showing adequate to good reliability ($\alpha = 0.72 - 0.89$). Translated items were taken from the validated German version [38].

We employed the Engaged Living Scale (ELS) [39] to assess an engaged response style as conceived in ACT [8].

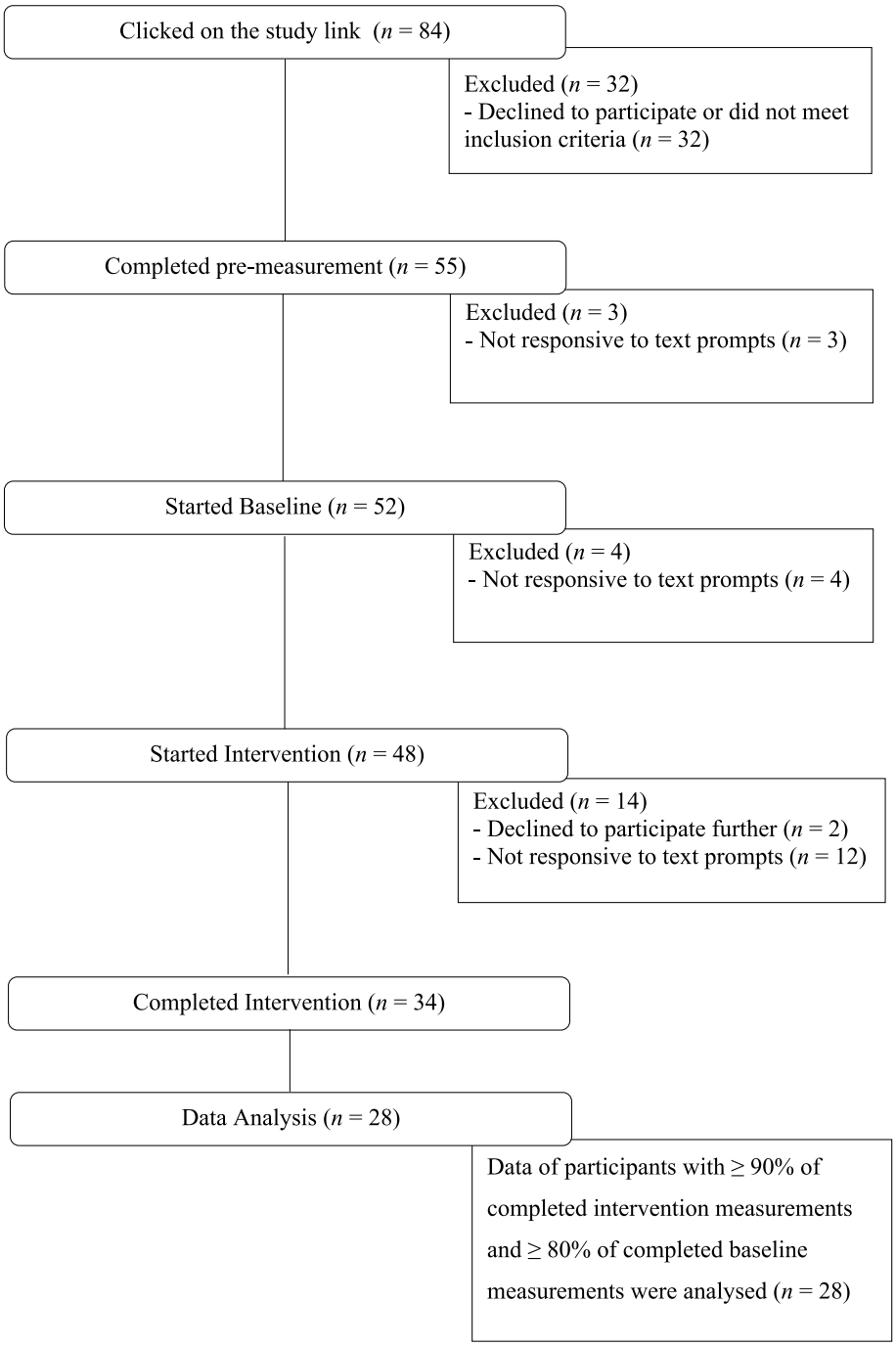

Fig. 2 CONSORT flow diagram of enrolment

The ELS consists of 16 items scored on a 5-point Likert scale and ranging from "completely disagree" to "completely agree". The ELS demonstrates excellent reliability ($\alpha = 0.92$ in a sample of chronic pain patients). Since there was no validated German version of the ELS, we had a non-psychologist native English speaker translate the questionnaire into German.

Additionally, participants were asked for how long they had been suffering from chronic pain and if they were taking medication for their pain. We also asked them to rate how useful psychotherapy seemed as a treatment for chronic pain (pre and post, 5-point Likert scale). After completing the last intervention module, participants were able to give us feedback on the course.

Table 1 Description of the intervention modules

Module 1: Overview	Introduction to values and the value compass-metaphor. Participants learn about values and why they are important.
Module 2: Values and pain	Participants learn why it might be difficult to live according to ones' values and how avoidance behaviour can interfere in trying to incorporate personal values into ones' life.
Module 3: My personal values	Participants are encouraged to engage with their own values in one of nine suggested areas of life.
Module 4: Goals	SMART goals are introduced. Participants are then encouraged to formulate one SMART value-based goal, which should be achievable during the following two days.
Modules 5 & 6: Short motivation	Participants receive a short motivational text which aims to encourage participants to achieve their set goal.
Module 7: Recapitulation	Participants are encouraged to reflect on the past two days about their set goal and goal achievement. Strategies to counter supposed failures in goal achievement are then presented.
Module 8: Barriers	Typical barriers (pain; organisational, financial and motivational hurdles) are introduced. For each type of barrier, participants receive suggestions on how to cope with them.
Module 9: Commitment	Referencing the last eight modules, participants are motivated and encouraged to make a decision towards a long-term commitment to live according to their values.
Module 10: Conclusion	Participants receive a summary of the most important content and final tips on how to incorporate personal values into their lives.

Items for daily measurements

Daily measures consisted of 8 items, which were extracted from the questionnaires used for pre- and post-measurements (Table 2). Selection criteria for the items were high factor loading on the relevant factor as well as an adequate verbal representation of the construct we aimed to assess. All items were presented on a 11-point Likert scale with verbally anchored scale endpoints.

Statistical analyses

Statistical analyses included the analysis of daily measures (individual and group level) as well as visual and descriptive analyses.

Daily measures

Since observations are nested within participants, it is necessary to take this hierarchical two-level structure into account [40]. MultiSCED, a tool specifically developed to analyse hierarchical SCED data taking a multilevel modelling approach [41], was used in our study for appropriate data analysis. Aggregated results from a two-level model make it feasible to generalise across cases. Individual one-level models offer regression-based parameter estimations for treatment effects during each participant's intervention phase (for more detailed information on MultiSCED, please refer to Declercq and colleagues, 2020 [41]).

Since we employed a replicated single-case AB phase design, conventional power considerations do not apply [40]. Moreover, sample size recommendations for multilevel analyses are typically not strict in terms of the assumed validity of the fixed effects [41]. Thus, considering the traditionally low number of cases in SCEDs [42], the sample size of $n = 28$ participants can be seen as a robust base for generalisation.

Table 2 Daily measures

Questionnaire	Item content
NRS	Please rate your average pain intensity.
WHO-5	I have felt active and vigorous.
WHO-5	My daily life has been filled with things that interest me.
PCS	I keep thinking about how badly I want the pain to stop.
CPAQ-8	I lead a full life even though I have chronic pain.
CPAQ-8	Before I can make any serious plans, I have to get some control over my pain.
ELS	I have values that give my life more meaning.
ELS	Nothing can stop me from doing something that's important to me.

Participants were asked to rate the items in regard to the past 24 h

NRS, Numerical Rating Scale; WHO-5, WHO Well-being Index; PCS, Pain Catastrophising Scale; CPAQ-8, Chronic Pain Acceptance Questionnaire 8-item version; ELS, Engaged Living Scale

Visual and descriptive analysis

Visual analysis usually plays a major role in single-case data analysis [43]. As in the study conducted by Simons and colleagues, raw data graphs for a treatment responder and non-responder were created to illustrate individual study courses. To determine if changes resulted from the implemented intervention and to systemise visual analysis, we relied on visual inspection criteria [43]. To quantify the magnitude of observed effects, nonoverlap of all pairs (NAP) effect sizes [44] were calculated, which equal the area under the curve (AUC) from a receiver operator characteristic curve (ROC) analysis [45].

Lastly, we checked whether the intervention led to a significant change in the perceived usefulness of psychotherapy for treating chronic pain by calculating a paired samples t-test with pre- and post-intervention means. We also analysed qualitative participant feedback descriptively.

Results

First, we describe participant characteristics. The results are then organised around the aggregated two-level results first, providing model-based inference regarding the mean change that occurs during the microintervention's course. Individual treatment courses are then highlighted by providing one-level results for one treatment responder and one non-responder, accompanied by visual analysis. Finally, we report the participants' feedback on the microintervention.

Participant characteristics

As indicated in Fig. 2, we analysed data of $n = 28$ participants. Our sample was predominantly female (85.7%), and participants had a mean age of 47 years (SD = 11.1). The participants had been suffering from chronic back pain for an average 15.6 years (SD = 10.6), and 60% of the sample were taking medication because of their pain. In the week preceding enrolment, their average pain intensity was 6.2 ($SD = 1.7$) on a 11-point NRS (Table 3).

Model-based inference

The one-level model per outcome and individual is described below, with subscript i specifying the measurement nested within a case

$$\Upsilon_i = \beta_0 + \beta_1 Time_i + \beta_2 Phase_i + \beta_3 (Time_i \times Phase_i) + e_i$$

The two-level model per outcome is described as

$$\Upsilon_{ij} = \beta_{0j} + \beta_{1j} Time_{ij} + \beta_{2j} Phase_{ij} + \beta_{3j} \left(Time_{ij} \times Phase_{ij}\right) + e_{ij}$$

with the additional subscript j denoting case j within the study. To facilitate a more comprehensive interpretation, the time variable was centered around the first day of the intervention.

Table 3 Participant characteristics

Variables	Single-case study participants ($N = 28$)
Age (y)[a]	47.0 ± 11.1
Gender, *n* (% female)	24 (85.7)
Occupational status, *n* (%)	
No occupation	9 (32.1)
Apprentice	1 (3.6)
Working	15 (53.6)
Pension	3 (10.7)
Pain duration (y)[a]	15.6 ± 10.6
Pain intensity[ab]	6.2 ± 1.7
On pain medication, *n* (% yes)	17 (60.7)

[a] values are presented as means (± standard deviation), *y* years, [b]in the week before the start of the study, assessed on a 11-point NRS

Aggregated multilevel modelling results of daily measures

On average, the baseline level for all outcomes is between 4 to 6 on the 11-point scale (Table 4). No average immediate effect on any of the outcomes is apparent at the beginning of the intervention phase. Likewise, we observed no significant treatment effect on the respective slopes for pain intensity, psychological wellbeing, or pain acceptance. We did, however, detect the microintervention's effect on the slopes of pain catastrophising and engaged living. The pain catastrophising score fell on average by 0.06 units per intervention day ($p < 0.05$). A similar pattern appears for the engaged living scale, which showed an average 0.07 units-per-day increase ($p < 0.05$).

Individual treatment courses

The individual treatment courses we observed and one-level results concur with the two-level results we report. We detected no significant or plausible effects of the intervention on individual intercepts or slopes regarding most participants and outcomes. The majority of treatment courses revealed either strong fluctuations in the baseline and treatment phases, or very little variability in the daily measures. The limited variability concerns in particular the items assessing pain catastrophising, pain acceptance, and engaged living.

The treatment course of one responder (ID 15) revealed an immediate intervention effect on the level of pain acceptance and engaged living measure. After the intervention started, we note an increase by 1.55 units ($p = 0.01$) and 4.10 units ($p < 0.001$) in pain acceptance and engaged living, respectively. Moreover, pain acceptance rose on average by 0.32 units ($p = 0.001$) and engaged living by 0.48 units per intervention day ($p = 0.001$). For psychological wellbeing however, we observed a significant treatment effect on the slope, indicating an average

Table 4 Two-level model estimations for outcomes from baseline to intervention

	Pain intensity	Wellbeing	Acceptance	Catastrophising	Engaged Living
Fixed effects					
Intercept (Υ_{00})	5.23	4.05	4.38	6.24	5.22
Intervention (Υ_{20})	0.27 (0.28)	0.47 (0.31)	0.08 (0.02)	−0.19 (0.16)	0.08 (0.21)
Intervention slope (Υ_{30})	0.02 (0.03)	0.03 (0.05)	0.05 (0.03)	−0.06 (0.03)*	0.07 (0.03)*
Variance between participants					
Intercept	2.02	1.69	2.06	2.88	2.09
Intervention	1.18	1.26	0.49	0.42	0.80
Intervention slope	0.09	0.19	0.12	0.12	0.10
Residual variance	1.11	1.30	0.73	0.93	0.92

* $p < 0.05$ *p*-Values based on Wald-type *t*-tests with Kenward-Roger's degrees of freedom approximation for fixed effects. The intercept (Υ_{00}) denotes the average baseline level. The time variable was centered around the first day of the intervention so that the parameter Υ_{20} expresses the average change in level at the start of the microintervention. The parameter Υ_{30} expresses the average slope in the intervention phase. Standard errors are given in parentheses. All outcomes were assessed on a 11-point Likert scale during baseline and intervention phase

decrease per day by 0.29 units ($p < 0.05$). Pain intensity and pain catastrophizing revealed no significant effects.

As the graph of ID 15 illustrates (Fig. 3), baseline and intervention phases for most scales do not appear to be stable, which makes it harder to interpret regression coefficients and draw valid conclusions. Moreover, even though significant effects have been obtained through MultiSCED, the extent of pain acceptance and engaged living barely exceeds those measures' baseline levels. This further weakens the impression of meaningful intervention effects, regardless of their statistical significance.

Visual inspection of daily measures of ID 15 reveals adequate variability within measures, however, no stable baseline could be documented. The only seemingly stable construct is pain acceptance, which remained on a medium level until the end of the baseline phase. A slight downward trend is apparent regarding engaged living. Wellbeing reveals an unchanged fluctuation level across phases regardless of the intervention start. Concordant with one-level results, only pain acceptance and engaged living changed meaningfully at the beginning of the intervention, stabilising on a relatively high level until the end of the treatment course (Acceptance NAP = 0.89 (95%-CI = 0.69 to 0.97); Engaged living NAP = 0.89 (95%-CI = 0.69 to 0.97)).

Figure 4 depicts a non-responder's treatment course (ID 17). Apart from one statistically significant effect of the intervention on the slope (NRS, $\beta_3 = 0.32$, $p = 0.002$) associated with the upward trend in measured pain intensity during the intervention phase, we observed no

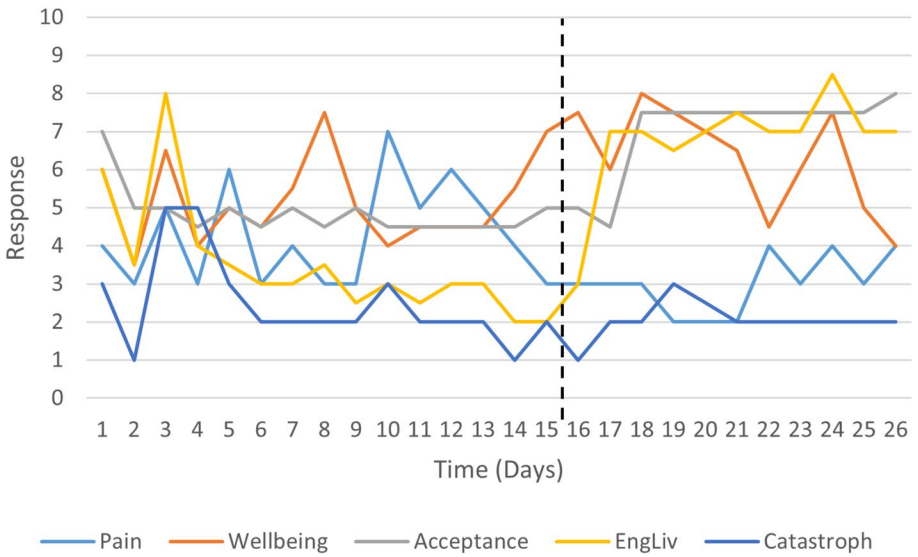

Fig. 3 Treatment course of a responder. Vertical line indicates phase change. Pain measured via NRS; Wellbeing, WHO-5; Pain Acceptance, CPAQ-8; Engaged Living, ELS; Pain Catastrophising, PCS

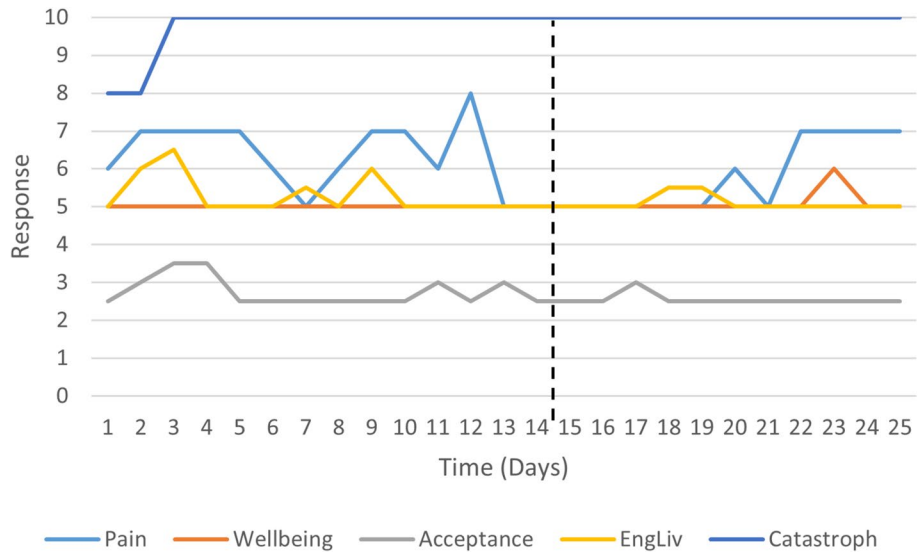

Fig. 4 Treatment course of a non-responder. Vertical line indicates phase change. Pain measured via NRS; Wellbeing, WHO-5; Pain Acceptance, CPAQ-8; Engaged Living, ELS; Pain Catastrophising, PCS

intervention effects on the slopes of outcome measures. Baseline phases of all measures apart from pain intensity seem relatively stable, and the microintervention's introduction triggers no change. Throughout the baseline and intervention phase, catastrophising remains on a high level, engaged living and wellbeing on a medium level, pain acceptance on a relatively low level. Pain intensity fluctuates between values 5 and 8, seemingly irrespective of phases. All individual graphs are available as supplemental digital content (Figure S1).

Inferring from their mean values, our participants found the intervention to be useful ($M = 3.85$; $SD = 1.17$) and that the integration of individually chosen values worked well ($M = 4.36$; $SD = 0.81$). Fourteen participants (50%) provided qualitative feedback on the intervention. Central to the positive feedback was the notion that the microintervention is a beneficial and useful reminder about values-based living, one that is easy to integrate into daily life ($n = 4$). Their constructive feedback concerned the length of the intervention (too long, $n = 1$; too short, $n = 1$) and the desire for more pain-focused psychoeducation ($n = 1$). Two participants found the intervention to be too general, not addressing complex pain syndromes sufficiently. A comprehensive table (Table S1) illustrating all feedback is available as supplemental digital content. The results of the paired samples t-test indicate a significant difference between the perceived usefulness of psychotherapy before the start of the microintervention ($M = 3.65$; $SD = 0.94$) and after its completion ($M = 4.62$; $SD = 0.90$; $t(25) = -5.95$, $p \leq 0.001$; $d_z = 1.17$).

Discussion

The aim of this single-case pilot study was to investigate the feasibility and effectiveness of a brief values-based microintervention in a sample of chronic back pain patients. In particular, we assumed we would observe the intervention's positive impact on pain intensity, pain acceptance, and engaged living, as well as catastrophising and wellbeing. Although individual participants benefited on individual scales, we were unable to demonstrate our intervention's effectiveness overall. The variance of individual items of the daily measurements revealed little variation for many participants. In contrast, some subjects showed a considerable amount of variation in their answers, which, however, could not be linked to the intervention. In their qualitative feedback, participants were generally positive about the microintervention. The perceived usefulness of psychotherapy in alleviating chronic pain increased after the intervention.

When comparing the responder to the non-responder, we initially notice that the non-responders demonstrated less overall variability in their daily measurements. The non-responder's course was characterised by high catastrophising and low acceptance. Pain catastrophising plays a major role in the perception of pain intensity and psychological distress [46]. Whereas a certain acceptance of pain is associated with better pain coping [47] and is considered a prerequisite for values-oriented actions [48]. Both constructs were already lower (catastrophising) or higher (acceptance) in the responder before the intervention. These initial baseline values could have influenced

their entire pattern of daily measurements. Accordingly, it is possible that the intervention was too advanced for the non-responder. Furthermore, note that the responders' values concerning engaged living and wellbeing fluctuate in the opposite direction with pain intensity. Since less pain intensity correlates with increased activity [49], it is possible that the low variability in most of the non-responders' scales is associated with their low variability in pain intensity.

Pain intensity tends to be a difficult construct to change. Psychotherapeutic treatments are known to have minimal if any effect on pain intensity [50]. Recently, the relevance of positive expectancy as a transdiagnostic factor has come increasingly into research focus [51]. Hope also plays an important role in chronic pain [52]. Accordingly, we hypothesised that the positive expectation of being able to experience a more engaged life again may lead to a small reduction in pain. As other online interventions have revealed positive effects on pain intensity compared to a waiting list control group [53], we suspect that our intervention was too short to enable a similar reduction in pain intensity.

We identified one responder for the pain acceptance and engaged living scales, but we detected no moderators as to why that particular subject responded positively to our intervention. Since values and acceptance are closely related [54] and the importance of acceptance of chronic back pain was repeatedly addressed in the intervention, we assumed that an increased values orientation would also lead to an increase in acceptance. From our survey, we conclude that a brief mobile course addressing the topic of acceptance and values-based action is insufficient to stimulate sustainable change in this regard. This conclusion is also supported by the observation that, according to patient reports, the acceptance of chronic pain is a process that takes a long time and also fluctuates over time [55]. In addition, the responses in the Chronic Pain Acceptance Questionnaire generally showed little variance.

Maintaining life activities despite pain is closely associated with both the acceptance of chronic pain and one's wellbeing [48]. Our hypothesis was that becoming aware of one's own values in an aspect of life would already lead to greater wellbeing, for example through a positive expectation to implement these values in the future [56]. On the basis of this study's findings, however, we assume that the subsequent and repeated action-oriented integration of these values into everyday life may be the more important factor. However, as wellbeing is a relatively stable construct over shorter periods of time [57], we believe that our interventions may have been be too brief to enable measurable change, or that changes only become apparent within a certain time span.

Since activity can reduce pain catastrophising [58], we hypothesised that values-based activity might have a similar effect. However, we did not monitor which activity the participants were engaged in. Since they were given only two activity tasks, we suspect that the activities were too brief to generate change. As psychoeducation about pain can reduce catastrophising [59], it might be helpful to precede future interventions with pain education. This was also requested in the qualitative feedback we received.

The results of this study provide valuable lessons for designing related surveys, as previous studies with similar content have demonstrated positive effects [53]. Rickardsson and colleagues successfully examined the effectiveness of an internet-based ACT intervention. Our survey failed to replicate their positive results, for example in terms of pain intensity and values. However, there were noticeable differences between these two studies: firstly, the study by Rickardsson and colleagues was conducted for 8 weeks, thus allowing for more extensive content to be conveyed. Secondly, their patients received feedback, support, and reminders. Thirdly, all their participants had at least one brief but direct contact with a therapist per week. Their intervention also involved much higher levels of exposure, which is an effective therapy component [60]. In direct comparison, the most obvious difference is that our study was much shorter and involved no human contact. Lin and colleagues [61] also demonstrated that an internet-based ACT intervention can yield positive results. However, at 7 weeks, their intervention was also much longer than ours. Their individual modules took about 60 min each. Therefore, our intervention was probably not long enough to reveal an improvement in the constructs we assessed. In addition, their study involved a guided condition with human involvement, which was also desired in some of the feedback we received.

Electronic health applications will certainly have a stronger impact on the field of medicine in the future [62]. They therefore deserve much more research. Although there have been promising studies on the effectiveness of eHealth in general [63] and health apps in particular [64], high quality evidence is still lacking on their overall effectiveness [17] and the effectiveness of individual components [65]. From our study results, we cannot conclude that values-based actions and pain acceptance are ineffective eHealth components. Based on the qualitative feedback we received, we conclude that shorter interventions could also find acceptance among subjects. Microinterventions could function as supportive measures before psychotherapy, or to enhance the perceived usefulness of psychotherapy as a treatment for chronic pain. However, we cautiously conclude that assessing

individual components may not perform well when taking our microintervention approach of addressing a single topic in a relatively short period of time. Instead, longer-term interventions seem to be better suited to create measurable change. In addition, qualitative analyses can help to extract effective components.

Our study has some limitations. First, the assessment of all constructs was based solely on self-report by our predominantly female sample. Furthermore, there was little variance in some scales during baseline and intervention phases, which could be due to our item selection, social desirability, or the assessment of relatively stable constructs. We did not assess neither type nor amount of pain medication that the participants took, which would have been helpful in order to estimate the impact that the medication could have had on the outcomes that we measured. Moreover, we only asked the subjects at the end whether they had done the tasks in the course, but we could not verify their answers' accuracy. Furthermore, participants could freely choose when they engaged in their daily assessments, which could have led to an assessment bias. Since pain intensity often fluctuates during the day, it would be plausible to assume that participants filled out the questionnaire when they were feeling relatively pain-free, preventing reliable measurements. Having only implemented two phases, the single-case design we chose enabled little generalisation. Furthermore, it would have been beneficial to have chronic back pain patients participate in developing the course.

Conclusion

The majority of participants in our study were satisfied with the microintervention, and stated that they benefited from the focus on personally meaningful values; furthermore, we observed an increase in the perceived usefulness of psychotherapy as a treatment for chronic pain. At the same time, we failed to observe such positive results in the daily measures. Future research could assess the minimum duration of chronic pain programmes to bring about clinically meaningful change and investigate whether narrowly focused microinterventions are beneficial as a low-threshold treatment prior to psychotherapy. Future single-case studies investigating microinterventions could begin by testing the trial's feasibility. This would ensure the adequacy of single items used for daily measures. Studies employing a SCED should also make use of the few brief assessment scales that have been developed especially for single-case studies, such as the 3-item Brief Acceptance Measure [66], which facilitates a brief assessment without having to use single items of larger instruments. To minimise the risk of biased assessments, future studies could include ecological momentary assessment features which could facilitate more frequent measures during the day without being too burdensome for participants.

Abbreviations

ACT	Acceptance and commitment therapy
AUC	Area under the curve
NAP	Nonoverlap of all pairs
ROC	Receiver operating characteristic
SCED	Single-case experimental design
SMART	Specific, measurable, achievable, relevant, time-bound

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s44247-023-00053-w.

Additional file 1: Figure S1 to S28. Individual treatment courses of ID 1 to ID 28.

Additional file 2: Table S1. Qualitative feedback on the microintervention.

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Authors' contributions

HJH, JR: inception and design of the study, drafting the protocol; SFZ: data acquisition, data analyses; HJH, SFZ: drafting of the manuscript, data interpretation; JAG, JR, WR: supervision, manuscript editing, reviewing; JR: project administration. All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

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Availability of data and materials

All data used and reported in this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Research involving human subjects complied with all relevant national regulations, institutional policies and is in accordance with the tenets of the Helsinki Declaration (as amended in 2013), and has been approved by the authors' Institutional Review Board (local ethics committee at the department of psychology of Philipps University of Marburg, reference number: 2021-85v). Informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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