Mindfulness practice time and quality in veterans with chronic pain

Hang Ruan, LICSW[a], Jennifer L. DelVentura, Ph.D.[a], Andrea C. Katz, Ph.D.[a], William J. Meyer, Ph.D.[a], Dustin S. Goerlitz, Ph.D[a], Jessica A. Chen, Ph.D.[ab], & Simon B. Goldberg, Ph.D.[c]

[a]VA Puget Sound Health Care System

[b]Dept. of Psychiatry and Behavioral Sciences, University of Washington School of Medicine

[c]Dept of Counseling Psychology and Center for Healthy Minds, University of Wisconsin - Madison

Corresponding author:

Hang Ruan, LICSW

Northwest Health Network (VISN 20)

U. S. Department of Veterans Affairs

1601 East Fourth Plain Blvd

Clark County Building #17, Suite 402

Vancouver, WA 98661

Telephone: 208-422-1000

hang.ruan@va.gov

DECLARATIONS

Ethics Approval:
Procedures described here were conducted as part of routine clinical care and were reviewed and approved as part of a Quality Improvement (QI) project by the local VA facility and therefore did not require IRB approval.

Informed Consent:
Procedures described here were conducted as part of routine clinical care. Since this was a QI project, informed consent to participate in research was not required by the VA IRB.

Author Contributions:

- Hang Ruan: Conceptualization, design, data collection, data analysis, writing, project administration
- Jennifer L. DelVentura: Conceptualization, design, data collection, data analysis, writing
- Andrea C. Katz: Data collection, data analysis, writing
- William J. Meyer: Data collection, data analysis, writing
- Dustin S. Goerlitz: Writing
- Jessica A. Chen: Conceptualization, design, formal analysis, data curation, visualization, writing
- Simon B. Goldberg: Conceptualization, design, formal analysis, data curation, visualization, writing, project supervision

Data Availability:
We share the analysis code within the manuscript. Due to VA restrictions, we are not able to share participant data.

Acknowledgments:
None

Funding:
None

Use of Artificial Intelligence:
None

Abstract

Objectives: Mindfulness interventions are associated with improvements in multiple areas of health, including chronic pain functioning, but little is known about how these improvements are best achieved in clinical settings.

Methods: The present study examined clinical outcomes in a structured mindfulness training protocol in a sample of 112 veterans with chronic pain. Mindfulness practice time and quality, as well as pain- and health-related outcome measures were collected at baseline, 1 month, and 2 months. Multilevel models were used to examine changes in outcomes from baseline to 2 months.

Results: Practice time and quality improved over the course of treatment. Self-reported well-being and health satisfaction also improved over time, although pain acceptance and pain interference did not. Those reporting steeper increases in practice quality over time reported greater improvements in quality of life. No associations were observed between practice quality and other outcomes nor between practice time and outcomes.

Conclusions: Results support a potential role of practice quality in producing improvements in quality of life among veterans with chronic pain. In contrast, practice time was not linked with outcomes. Future randomized trials comparing this protocol to a control group are warranted to further elucidate clinical effects and mechanisms and to clarify the roles of practice time and practice quality within this population.

Keywords: mindfulness; chronic pain; veterans; practice quality; practice time

Mindfulness practice time and quality in veterans with chronic pain

According to the Centers for Disease Control and Prevention (CDC), an estimated 51.6 million Americans (20.9% of the population) experienced chronic pain in 2021. Of those, 17.1 million experienced high-impact chronic pain, which significantly interferes with daily activities (Rikard et al., 2023). Chronic pain costs the United States healthcare system between $560-$635 billion dollars per year (Smith and Hilner, 2019; Hadi et al., 2019). Among veterans, chronic pain prevalence is even higher; up to 65.6% of veterans report pain over the last three months, and severe pain was 40% greater in veterans compared to non-veterans (Nahin, 2017). Furthermore, there is higher prevalence of post-traumatic stress disorder (PTSD) in veterans than the general population, and there is consistent evidence that chronic pain is associated with PTSD (Fishbain et al., 2017; Reed, Fischer, et al., 2024). For these reasons, pain management is a top priority within the Veterans Affairs system (Scorsone & Frank, 2024).

Chronic pain can interfere with multiple areas of life, including physical functioning, professional life, relationships, sleep, and mood (Hadi et al., 2019). In addition to decreased overall quality of life, chronic pain affects mental health (Hadi et al., 2019). Indeed, depression and anxiety often co-occur with chronic pain. Whereas major depressive disorder is observed in approximately 5% of the general population, it has been associated with 30-45% of those with chronic pain (Vadivelu et al., 2017). Similarly, a recent study demonstrated that anxiety is often worse in adults with chronic pain (Mullins et al., 2023).

Mindfulness and Chronic Pain

Interventions based on mindfulness (i.e., non-judgmental awareness of the present moment; Kabat-Zinn, 1994) have emerged as promising standalone interventions and a

component of other interventions for chronic pain. Numerous mindfulness-based interventions (MBIs) have shown efficacy in improving pain and pain-related symptoms, as well as psychological outcomes linked with chronic pain (e.g., depression, anxiety, and quality of life; Goldberg et al., 2022; Goyal, 2014; Hilton et al., 2017; Kabat-Zinn, 1985; Piet and Hougaard, 2011; Rosenzweig et al., 2009). Indeed, chronic pain was one of the first clinical targets to show promising effects from mindfulness training (Kabat-Zinn, 1985). A network meta-analysis found MBIs to be similarly effective to cognitive behavioral therapy for chronic pain (CBT-CP; Khoo et al., 2019), a gold-standard behavioral treatment for chronic pain. This result was more recently replicated in a large-scale randomized trial comparing these two approaches (Zgierska et al., 2025). Unique neurophysiological mechanisms have even been associated with mindfulness-based pain relief, supporting its utility as a complementary and integrative treatment approach for acute and chronic pain (Jinich-Diamant et al., 2020; Zeidan et al., 2016).

Beyond gold-standard MBIs, like mindfulness-based stress reduction (MBSR, Kabat-Zinn et al., 1985), other new, promising MBIs for chronic pain have also emerged, such as Mindfulness-Oriented Recovery Enhancement (MORE; Garland, 2020). Similar to MBSR, MORE was designed to address chronic pain, particularly when comorbid with substance use disorders (Garland, 2020). A meta-analysis of eight randomized trials testing the effects of MORE demonstrate consistent benefits on measures of chronic pain, addictive behaviors, and psychiatric symptoms (Parisi et al., 2022).

As with any behavioral intervention, consistent, at-home mindfulness practice is theoretically important to obtain beneficial outcomes (Goldberg et al., 2014; McClintock et al., 2019; Wachholtz et al., 2019). However, at-home mindfulness practice is far from a perfect predictor of outcomes (Goldberg et al., in press; Parsons et al., 2017). There is some evidence to

suggest that various aspects beyond the amount of at-home practice are also associated with outcomes, perhaps even more so than amount of practice (Goldberg, 2022). Mindfulness practice quality has emerged as a candidate characteristic that may be linked to outcomes at times above and beyond amount of at-home practice (Goldberg et al., 2014). Mindfulness practice quality has been defined as the degree to which an individual is applying mindfulness techniques as instructed during formal meditation practice (Del Re et al., 2013). Although mindfulness practice quality has been shown to relate to changes in various measures of psychological distress (e.g., Del Re et al., 2022; Goldberg et al., 2014, 2020; Strohmaier & Goldberg, in press), its potential role in the context of mindfulness-based pain management is unclear. Clarifying the link between both at-home practice time and practice quality is important for supporting clinicians and patients efforts applying mindfulness to the management of chronic pain.

Present Study Aims and Hypotheses

The present study investigated the implementation of a mindfulness training program for veterans with chronic pain and its impacts on mindfulness practice quality (Mindfulness Practice Quality – [PQM]; Del Re et al., 2013) and other mindfulness- and pain-related outcomes over time. We examined changes in the amount of formal, at-home practice time and PQM, as well as pain acceptance, pain interference, and health-related quality of life over the course of the program and afterward. A secondary aim of the study was to assess outcomes within a real-world clinical setting – a pain specialty clinic within the Veterans Affairs (VA) health system. This study was preregistered through the Open Science Framework (https://osf.io/67za5/?view_only=6ffe4c10ea1a42089d2d5890cf2cf560). Based on input from an anonymous reviewer, we number our hypotheses differently than listed in our preregistration. However, we tested the same set of hypotheses detailed in our preregistration.

Hypotheses:

Hypothesis 1: Pain acceptance improves over the course of treatment.

Hypothesis 2: Pain interference improves over the course of treatment.

Hypothesis 3: Quality of life improves over the course of treatment.

Hypothesis 4: Mindfulness practice quality increases over the course of treatment.

Hypothesis 5: Changes in mindfulness practice quality are positively associated with formal practice time.

Hypothesis 6: Greater practice time and greater increases in PQM are associated with improvements in pain acceptance.

Hypothesis 7: Greater practice time and greater increases in PQM are associated with improvements in pain interference.

Hypothesis 8: Greater practice time and greater increases in PQM are associated with improvements in quality of life.

Methods

Participants

Participants were recruited from pain management clinics housed within two large regional VA facilities, as well as from a subsidiary program serving veterans throughout the northwest region of the United States. Eligible participants were veterans with chronic non-cancer pain (of at least 3-6 months duration) who were motivated to participate in a mindfulness training intervention. There were no explicit exclusion criteria; however, for veterans with active psychosis or suicidal ideation, stabilization of these symptoms was prioritized prior to participation. All participants engaged in the mindfulness training program (see Table 1 for Mindfulness Training Program Clinical Protocol) as part of routine clinical care and either self-referred or were referred by a pain clinic/regional pain program mental health provider. A total

of 112 veterans enrolled in the program during the data collection phase which occurred from June 2020 through July 2023.

Measures

Formal Practice Time

Participants were asked to report the average number of minutes per day of formal mindfulness practice over the past week. Formal mindfulness practice was defined as planned practices scheduled throughout the day or week. Similar measures of formal practice time have been used in prior studies (Parsons et al., 2017).

Mindfulness Practice Quality (PQM)

We used the single-item PQM which is a self-report rating of mindfulness practice quality (Goldberg et al., 2020). This item is derived from earlier multi-item measures (Del Re et al., 2013) and has demonstrated acceptable test-retest reliability, sensitivity to change, predictive validity (i.e., predicting improved psychological functioning; Goldberg et al., 2020). Scores range from 1 (“Low quality”) to 10 (“High quality”) on a Likert-type scale.

Pain, Enjoyment of Life and General Activity (PEG) Scale—Interference with Enjoyment of Life Item.

The PEG was developed as an “ultra-brief” 3-item measure of pain severity and interference developed and validated for patients with chronic pain, including veteran populations (Krebs et al., 2009). PEG scores have demonstrated responsiveness to change over time (Reed, Stump, O'Monahan, & Kroenke, 2024). For the present study, only the second item of the PEG, assessing pain interference with enjoyment of life, was used. Scores range from 0 (“Does not interfere”) to 10 (“Completely interferes”) on a Likert-type scale.

Chronic Pain Acceptance Questionnaire-8 (CPAQ-8)

The CPAQ-8 is an abbreviated, validated version (Fish et al., 2010) of the original 20-item CPAQ (McCracken, Vowles, & Eccleston, 2004). Scores on the CPAQ-8 correlate highly with the 20-item version (Fish et al., 2020). Participants rated how "true" they found eight statements on a 0 ("Never true") to 6 ("Always true") Likert-type scale, with higher scores indicating greater pain acceptance. Higher scores are associated with lower healthcare utilization for pain, lower depression and anxiety scores, and lower intensity and interference of pain (Fish et al., 2010). Coefficient alpha for this sample was 0.78 for the total score and coefficient omega was 0.88, indicating adequate internal consistency reliability.

World Health Organization-5 Well-being Index (WHO-5)

The WHO-5 is a widely used 5-item measure assessing self-reported psychological well-being. It is a validated briefer version of the WHO-10 (Bech, Gudex, & Staehr Johansen, 1996) and an earlier 28-item measure (Warr, Banks, & Ullah, 1985). It has been used as a screening tool for depression (Schneider, et al., 2010) and scores have also been found to be associated with post-cardiac event outcomes (Bergmann, et al., 2013) and adaptive coping styles (Garnefski, Kraaij, Schroevers, & Somsen, 2008). Each item is scored on a Likert-type scale from 0 ("At no time") to 5 ("All of the time"). Scores are then summed for a total of 0-25, then multiplied by 4 for a score range of 0-100. Higher scores on this measure indicate greater well-being, and a ten-point change is considered the threshold for clinical significance (Bech, Lunde, Bech-Andersen, Lindberg, & Martiny, 2007). Coefficient alpha for this sample was 0.86 and coefficient omega was 0.89 respectively, indicating satisfactory internal consistency reliability.

World Health Organization Quality of Life-Brief Version (WHOQOL-BREF) Items 1 & 2

These two items provide overall ratings of one's quality of life and satisfaction with health. They are drawn from the larger WHOQOL-BREF, a widely used and validated

assessment of quality of life (WHOQOL Group, 1998). Scores for these items range from 1 ("Very Poor") to 5 ("Very Good") on a Likert-type scale. Internal consistency reliability cannot be calculated for a single-item scale.

Administration of Measures

Formal Practice Time, Mindfulness Practice Quality, and Pain Interference with Enjoyment of Life were administered at each session. CPAQ-8, WHO-5, and WHOQOL-BREF were administered at multiple time points throughout treatment to assess effects of the intervention over time. Measurement time points included: baseline (session 1), 1 month (session 4), and 2 months (session 8). Measures were selected based on their demonstrated validity, reliability, brevity (to limit patient burden), and clinical utility as a part of clinical program evaluation (see Table 2 for session structure and measures collected).

Procedures

Procedures described here were conducted as part of routine clinical care and were reviewed and approved as part of a Quality Improvement (QI) project by the local VA facility and therefore did not require Institutional Review Board approval. Participants were enrolled on a rolling basis. After enrollment, veterans completed an intake, during which the clinician collected information about past experience with mindfulness practice, current pain functioning, and goals for the program. The mindfulness training program was designed as a multiphase program including individual and group modalities. Program enrollment began with eight weekly individual sessions (Foundation Phase), followed by biweekly to monthly individual sessions (Intermediate Phase and Continuing Care Phase, respectively). During the intermediate and continuing care phases, veterans could opt into a weekly mindfulness practice group. Both individual and weekly group sessions followed an established mindfulness protocol in terms of structure and approach (Ruan, Pocock, & Ruan, 2023) which includes a combination of

discussion and experiential practice in each session (see Tables 1 and 2). Self-report measures were collected at each individual and group visit. Outcome measures and demographic information were collected at baseline (i.e., session 1 of the training program); outcome measures were collected 1 month, and 2 months after baseline. As these measures were used as part of routine clinical care, veterans received feedback about the scores.

Data Analysis

Data analysis was conducted in R (R Core Team, 2022). Analysis code is provided in Supplemental Appendix 1. Due to restrictions within the VA system, we are unable to share participant data. To examine longitudinal changes in all outcomes we used two-level multilevel models in the 'lme4' package (Bates et al., 2015) with observations nested within participants. For outcomes that were measured at each group meeting (i.e., pain interference, practice quality), we modeled the day of assessment. For outcomes that were measured monthly (i.e., pain acceptance, quality of life), we modeled the month of assessment. The basic multilevel model was:

$$Y_{ij} = \beta_{00} + \beta_{10} * (Time) + [U_{0j} + U_{1j} * (Time) + e_{ij}], \quad \text{(Equation 1)}$$

where Y_{ij} reflects the outcome (e.g., pain interference) for participant *i* at time *j*. The fixed intercept (β_{00}) reflects the overall mean at time 0. The fixed slope (β_{01}) reflects the overall change in the outcome per unit time (i.e., day or month). The random intercept (U_{0j}) reflects the variability around the fixed intercept for participant *j*. The random slope (U_{1j}) reflects the variability around the fixed slope for participant *j*. Note that random slopes were only fit for the outcomes with weekly assessment as insufficient data were available for modeling random slopes for the monthly assessments. Lastly, e_{ij} reflects the residual (i.e., error) variance for participant *i* at time *j*.

To examine whether increases in practice quality were associated with greater formal practice time, we included an interaction term between participants' formal meditation practice time (aggregated across the 60 days of assessment) and time (of assessment):

$$Y_{ij} = \beta_{00} + \beta_{10} * (Time) + \beta_{01} * (Formal\ Practice) + \beta_{11} * (Time\ X\ Formal\ Practice) + [U_{0j} + U_{1j} * (Time) + e_{ij}], \quad \text{(Equation 2)}$$

where β_{01} reflects the fixed effect of formal practice (a participant-level variable) and β_{11} reflects the fixed effect for the interaction of time (of assessment) and formal practice time. All other model components are as in Equation 1.

Last, we examined whether changes in practice quality and amount of formal practice were associated with changes in pain acceptance and quality of life. To assess this, we first extracted random slope coefficients (using Equation 1) to characterize changes in practice quality. We then examined the interaction between time and either practice quality random slope coefficients or aggregate formal practice time. Models were equivalent to Equation 2, but with practice quality slopes entered in place of formal practice time for models examining practice quality as the predictor.

During analysis, we deviated from the preregistration in one way. We added an analysis examining whether formal practice time increased from intake to 2 months because the clinical team deemed it clinically relevant.

Results

Sample Characteristics

The full sample consisted of 112 unique individuals who participated in the mindfulness training protocol. Because some individuals participated only in group mindfulness training (not

individual), we utilized two different analytic samples: the full cohort of 112 individuals who completed weekly assessments at each group meeting (formal practice time, mindfulness practice quality, and pain interference) and 82 individuals who completed an individual baseline assessment and monthly follow-up assessments. Demographic characteristics are only available for the sample that completed an individual baseline assessment.

Characteristics of the baseline sample of 82 veterans are reported in Table 3. The mean age was 50.35 years (*SD* = 13.47, median = 51 years), and the sample consisted of approximately two-thirds men and one-third women. The racial and ethnic makeup of the sample was similar to the demographic makeup of the surrounding geographic region, with 68.29% of the sample self-identifying as White, 14.63% as African American, 8.54% as Asian, 4.88% as multiracial, and the remaining sample identifying as Latinx, Middle Eastern, or declining to report race/ethnicity.

At baseline, the mean practice quality (PQM) in the sample was 4.82 (*SD* = 2.15) on a 1-10 scale, and mean pain interference was 6.76 (*SD* = 2.01) on a 0-10 scale. By the 2-month follow-up, the overall mean practice quality (PQM) was 5.91 (*SD* = 2.13) and mean pain interference was 6.76 (*SD* = 2.04).

Changes in Clinical Outcomes

Neither pain acceptance (*B* = 0.78, *SE* = 0.42, *p* = .069) nor pain interference (*B* = 0.00014, *SE* = = 0.0050, *p* = .978) improved significantly from baseline to 2-month follow-up. Subjective well-being significantly improved from baseline to 2 months (*B* = 0.25, *SE* = 0.058, *p* = .003). Quality of life did not improve significantly (*B* = 0.090, *SE* = 0.068, *p* = .187), but satisfaction with health did (*B* = 0.24, *SE* = 0.061, *p* < .001). Figure 1 shows changes from baseline to 2 months for pain acceptance (CPAQ-8 total), subjective well-being (WHO-5), quality of life (WHOQOL-BREF, question 1), and satisfaction with health (WHOQOL-BREF,

question 2). Table 4 reports the means and standard deviations of clinical outcomes at baseline, 1 month, and 2 months.

Changes in mindfulness formal practice time and practice quality

Mindfulness practice quality (PQM) improved from baseline to 2-month follow-up when modeling change using a linear function ($B = 0.028$, $SE = 0.0059$, $p < .001$; Figure 2), Adding quadratic or cubic terms to the models did not improve fit (see Supplemental Table 1 for planned sensitivity analyses).

Formal practice time significantly increased from intake to 2-month follow-up ($B = 0.18$, $SE = 0.039$, $p < .001$). To examine whether those who report longer practice times showed a steeper increase in practice quality, we tested formal practice time as a moderator of the slope of change in practice quality. Formal practice was not a significant moderator (Supplemental Table 2).

Mindfulness practice time, practice quality, and clinical improvement

Greater formal practice time was not associated with improvements in pain interference (time X formal practice $B = -0.000012$, $SE = 0.00047$, $p = .980$), pain acceptance (time X formal practice $B = -0.084$, $SE = 0.059$, $p = .153$), subjective well-being (time X formal practice $B = 0.0082$, $SE = 0.0081$, $p = .313$), quality of life (time X formal practice $B = 0.00057$, $SE = 0.0093$, $p = .951$), or satisfaction with health (time X formal practice $B = -0.0013$, $SE = 0.0084$, $p = .877$).

Improvements in mindfulness practice quality were significantly associated with improvements in quality of life (time X PQM slope $B = 20.98$, $SE = 7.69$, $p = .008$; Figure 3) but not with pain acceptance (time X PQM slope $B = 26.46$, $SE = 50.43$, $p = .601$), subjective well-being (time X PQM slope $B = 8.89$, $SE = 6.88$, $p = .199$), nor satisfaction with health (time X PQM slope $B = 5.44$, $SE = 7.16$, $p = .449$).

Discussion

Our study examined data drawn from a structured mindfulness training program for veterans with chronic pain on mindfulness- and pain-related outcomes. Outcomes included mindfulness practice quality, mindfulness practice time (i.e., quantity), pain acceptance, pain interference, quality of life, and satisfaction with health. In line with our hypotheses, mindfulness practice quality increased over the course of the program. Formal practice time also increased. Interestingly, the amount of formal practice was not associated with longitudinal changes in practice quality. Subjective well-being and satisfaction with health also improved at 2-month follow-up. Supporting a potential role for practice quality in producing beneficial effects from mindfulness training, improved mindfulness practice quality was associated with improved quality of life. Contrary to our hypotheses, pain acceptance, pain interference, and quality of life did not improve from baseline to 2-month follow-up. Moreover, mindfulness practice quality was not associated with changes in pain acceptance, subjective well-being, or satisfaction with health. Formal mindfulness practice time was not associated with improvements in any of the outcomes we measured (i.e., pain interference, pain acceptance, subjective well-being, quality of life, satisfaction with health).

Our results provide mixed support for a potential role of practice quality within this context. The current study replicates prior results showing associations between practice time and practice quality (Goldberg et al., 2020) and mirrors studies that have also found practice time to be less predictive of mindfulness and psychosocial outcomes than practice quality (Goldberg et al., 2014, 2020; Ribeiro et al., 2018; Strohmaier et al., 2021). In line with those findings, the current study found improved mindfulness practice quality, but not quantity, to be associated with improved quality of life. Nonetheless, although prior studies have found increases in

practice quality to be associated with improvements in multiple psychosocial outcomes (e.g., depression, anxiety, and stress), the current study found practice quality to be associated only with quality of life and not with the other measured outcomes. One possible explanation is the outcomes included in the current study differed from prior studies in important ways. For example, whereas prior studies focused on stress, depression, and quality of life (Goldberg et al., 2014, 2020; Ribeiro et al., 2018; Strohmaier et al., 2021), the current study's outcomes were primarily pain-focused (i.e., pain acceptance, pain interference, quality of life, and satisfaction with health). Another factor is the study's veteran sample. As has been shown, veterans typically have greater chronic pain severity than the general population (Nahin, 2017), so process variables like practice quality may for this reason have been less impactful than in other populations.

We did see improvements over time for several outcome measures, supporting the possibility that mindfulness training may improve at least some outcomes for veterans with chronic pain. The program in the current study primarily involved individual sessions but also included optional group sessions, which are rarely offered outside of formal MBSR groups. Based on the study results, this flexible and tailored approach may improve both mindfulness practice quality as well as subjective well-being and satisfaction with health, even if it does not result in improvements in pain-specific outcomes. Notably, these effects are observed outside the context of a clinical trial and with minimal inclusion/exclusion criteria applied to group membership. As the current study addresses a potentially vital aspect of MBIs for chronic pain (i.e., how to support cultivation of enduring quality mindfulness practice within routine care), future research can explore methods to increase efficacy on pain-specific outcomes, potentially via further harnessing practice quality. Next steps may include qualitative research assessing

patient perspectives on how their mindfulness practice can be improved and examining barriers and facilitators for integrating these practices into their daily life (Marks et al., 2023; Xie et al., 2024). This may also include measurement-based care, in which interventions are adjusted based on participant data throughout the interventions (Fortney et al., 2017).

Limitations

This study has several important limitations. Veterans were not randomized to a condition, as participation in the MBI was part of usual care. Without randomization, we were unable to assess between-group differences (e.g., with comparison to a control group), and thus cannot evaluate whether any observed changes are in fact attributable to the MBI. Most analyses were also limited to 82 which was below our preregistered target sample size of 100. This may have resulted in low power for some tests and possible Type II error. Information regarding external factors such as medication use, psychological comorbidities, or concurrent therapies was not available as part of this study and thus not controlled for. The study predominantly consisted of white male veterans which limits generalization to other groups. Future research would benefit from replication with more diverse populations with regard to race, ethnicity, and gender. All measures were self-reported which have known biases (e.g., social desirability).

Summary

The current study examined mindfulness practice quality, practice time, and clinical outcomes within the context of an individualized mindfulness program for veterans with chronic pain. Participants reported increased mindfulness practice quality, practice time, and improved satisfaction with health and subjective well-being but no significant improvement on pain-specific measures. Improvement in practice quality was associated with improvements in quality

of life (but no other outcomes) while practice time was not linked with outcomes. Taken together, results suggest that mindfulness training for veterans may improve some aspects of well-being and that mindfulness practice quality may be an important mechanism worthy of further investigation in this population. Future iterations of mindfulness training for veterans may benefit from strategies that have been shown to impact pain directly (e.g., MORE; Garland et al., 2020).

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1-48. doi:10.18637/jss.v067.i01

Bech, P., Gudex, C., & Staehr Johansen, K. (1996). The WHO (Ten) Well-Being Index: validation in diabetes. *Psychotherapy and Psychosomatics, 65*, 183-190.

Bech, P., Lunde, M., Bech-Andersen, G., Lindberg, L., & Martiny, K. (2007). Psychiatric outcome studies 9POS): does treatment help the patients? A Popperian approach to research in clinical psychiatry. *Nordic Journal of Psychiatry, 61*(suppl 46), 4-34.

Bergmann, N., Ballegaard, S., Holmager, P., Kristiansen, J., Gyntelberg, F., Andersen, L. J., . . . Faber, J. (2013). Pressure pain sensitivity: a new method of stress measurement in patients with ischemic heart disease. *Scand J Clin Lab Invest, 73*, 373-379.

Flückiger, C., & Goldberg, S. B. (2022). Practice Quality-Mindfulness (PQ-M). In Medvedev, O. N., Krägeloh, C. U., Siegert, R. J., Singh, N. N. (Eds.), *Handbook of Assessment in Mindfulness Research* (pp. 1-12). Cham: Springer International Publishing.

Del Re, A. C., Fluckiger, C., Goldberg, S. B., & Hoyt, W. T. (2013). Monitoring mindfulness practice quality: An important consideration in mindfulness practice. *Psychotherapy Research, 23*(1), 54-66. doi:10.1080/10503307.2012.729275

Development of the World Health Organization WHOQOL-BREF quality of life assessment. (1998). *Psychological Medicine, 28*(3), 551–558. Retrieved from https://doi.org/10.1017/s0033291798006667

Fish, R. A., McGuire, B., Hogan, M., Morrison, T., & Stewart, I. (2010). Validation of the Chronic Pain Acceptance Questionnaire (CPAQ) in an Internet sample and development and preliminary validation of the CPAQ-8. *Pain, 149*(3), 435-443. doi:10.1016/j.pain.2009.12.016

Fishbain, D. A., Pulikal, A., Lewis, J. E., & Gao, J. (2017). Chronic Pain Types Differ in Their Reported Prevalence of Post -Traumatic Stress Disorder (PTSD) and There Is Consistent Evidence That Chronic Pain Is Associated with PTSD: An Evidence-Based Structured Systematic Review. *Pain medicine (Malden, Mass.)*, *18*(4), 711–735. https://doi.org/10.1093/pm/pnw065

Fortney, J. C., Unützer, J., Wrenn, G., Pyne, J. M., Smith, G. R., Schoenbaum, M., & Harbin, H. T. (2017). A tipping point for measurement-based care. *Psychiatric Services, 68*(2), 179-188. doi: 10.1176/appi.ps.201500439

Garland, E. L. (2020). Psychosocial intervention and the reward system in pain and opioid misuse: new opportunities and directions, *Pain*, *161*(12):2659-2666. doi:10.1097/j.pain.0000000000001988

Garnefski, N., Kraaij, V., Schroevers, M. J., & Somsen, G. A. (2008). Post-traumatic growth afer a myocardial infarction: a matter of peresonality, psychological health, or cognitive coping? *Journal of Clinical Psychology in Medical Settings, 15*, 270-277.

Goldberg, S. B. (2022). A common factors perspective on mindfulness-based interventions. *Nature Reviews Psychology, 1*, 605-619. doi: 10.1038/s44159-022-00090-8

Goldberg, S. B., Del Re, A. C., Hoyt, W. T., & Davis, J. M. (2014). The secret ingredient in mindfulness interventions? A case for practice quality over quantity. *Journal of Counseling Psychology*, *61*(3), 491–497. https://doi.org/10.1037/cou0000032

Goldberg, S. B., Kendall, A. D., Hirshberg, M. J., Dahl, C. J., Nahum-Shani, I., Davidson, R. J., & Bray, B. C. (in press). Is dosage of a meditation app associated with changes in psychological distress? It depends on how you ask. *Clinical Psychological Science*.

Goldberg, S. B., Knoeppel, C., Davidson, R. J., & Flook. L. (2020). Does practice quality mediate the relationship between practice time and outcome in mindfulness-based stress reduction? *Journal of Counseling Psychology, 67*(1), 115-122. doi: 10.1037/cou0000369

Goldberg, S. B., Riordan, K., Sun, S., & Davidson, R. J. (2022). The empirical status of mindfulness-based interventions: A systematic review of 44 meta-analyses of randomized controlled trials. *Perspectives on Psychological Science, 17*(1), 108-130. doi: 10.1177/1745691620968771

Goyal, M., Singh, S., Sibinga, E.M., Gould, N.F., Rowland-Seymour, A., Sharma, R., Haythornthwaite, J.A. (2014). Meditation programs for psychological stress and well-being: A systematic review and meta-analysis. *JAMA Internal Medicine*, *174*(3), 357–368. doi: 10.1001/jamainternmed.2013.13018.

Hadi, M.A., McHugh, G.A., Closs, S.J. (2019). Impact of Chronic Pain on Patients' Quality of Life: A Comparative Mixed-Methods Study. *Journal of Patient Experience*, *6*(2),133-141. doi: 10.1177/2374373518786013. Epub 2018 Jul 5. PMID: 31218259; PMCID: PMC6558939.

Hilton, L., Hempel, S., Ewing, B. A., Apaydin, E., Xenakis, L., Newberry, S., Colaiaco, B., Maher, A. R., Shanman, R. M., Sorbero, M. E., & Maglione, M. A. (2017). Mindfulness Meditation for Chronic Pain: Systematic Review and Meta-analysis. *Annals of Behavioral Medicine*, *51*(2), 199–213. https://doi.org/10.1007/s12160-016-9844-2

Jinich-Diamant, A., Garland, E., Baumgartner, J., Gonzalez, N., Riegner, G., Birenbaum, J., Case, L., & Zeidan, F. (2020). Neurophysiological Mechanisms Supporting Mindfulness Meditation–Based Pain Relief: An Updated Review. *Current Pain and Headache Reports*, *24*(10), 56. https://doi.org/10.1007/s11916-020-00890-8

Kabat-Zinn, J., Lipworth, L., Burney, R. (1985). The clinical use of mindfulness meditation for the self-regulation of chronic pain. *Journal of behavioral medicine*, *8*:163–190.

Kabat-Zinn, J. (1994). *Wherever you go, there you are: Mindfulness meditation in everyday life.* New York: Hyperion.

Khoo, E-L., Small, R., Cheng, W., Hatchard, T., Glynn B., Rice, D.B., Skidmore, B., Kenny, S., Hutton, B., Poulin, P.A. (2019). Comparative evaluation of group-based mindfulness based stress reduction and cognitive behavioural therapy for the treatment and management of chronic pain: A systematic review and network meta-analysis. *Evidence Based Mental Health, 22*, 26–35.

Krebs, E. E., Lorenz, K. A., Bair, M. J., Damush, T. M., Wu, J., Sutherland, J. M., . . . Kroenke, K. (2009). Development and Initial Validation of the PEG, a Three-item Scale Assessing Pain Intensity and Interference. *Journal of General Internal Medicine, 24*(6), 733-738. doi:10.1007/s11606-009-0981-1

Marks, E., Moghaddam, N., De Boos, D., & Malins, S. (2023). A systematic review of the barriers and facilitators to adherence to mindfulness-based cognitive therapy for those with chronic conditions. *British Journal of Health Psychology, 28*(2), 338-365.

McClintock, A. S., McCarrick, S. M., Garland, E. L., Zeidan, F., & Zgierska, A. E. (2019). Brief Mindfulness-Based Interventions for Acute and Chronic Pain: A Systematic Review. *Journal of Alternative and Complementary Medicine*, *25*(3), 265–278. https://doi.org/10.1089/acm.2018.0351

McCracken, L. M., Vowles, K. E., & Eccleston, C. (2004). The Chronic Pain Acceptance Questionnaire: Confirmatory factor analysis and identification of patient subgroups. *Pain, 107*, 15-166.

Mullins, P.M., Yong, R.J., Bhattacharyya, N. (2023). Associations between chronic pain, anxiety, and depression among adults in the United States. *Pain Practice Journal*, *23*(6), 589-594. doi: 10.1111/papr.13220. Epub 2023 Mar 14. PMID: 36881021.

Nahin, R.L., Severe Pain in Veterans: The Effect of Age and Sex, and Comparisons With the General Population (2017). *The Journal of Pain*, *18*(3), 247-254. doi: 10.1016/j.jpain.2016.10.021. Epub 2016 Nov 21. PMID: 27884688; PMCID: PMC5337168.

Parisi, A., Roberts, R. L., Hanley, A. W., & Garland, E. L. (2022). Mindfulness-Oriented Recovery Enhancement for addictive behavior, psychiatric distress, and chronic pain: A multilevel meta-analysis of randomized controlled trials. *Mindfulness, 13*(10), 2396-2412.

Parsons, C. E., Crane, C., Parsons, L. J., Fjorback, L. O., & Kuyken, W. (2017). Home practice in Mindfulness-Based Cognitive Therapy and Mindfulness-Based Stress Reduction: A systematic review and meta-analysis of participants' mindfulness practice and its association with outcomes. *Behaviour Research and Therapy, 95*, 29-41. doi: 10.1016/j.brat.2017.05.004

Piet, J., & Hougaard, E. (2011). The effect of mindfulness-based cognitive therapy for prevention of relapse in recurrent major depressive disorder: A systematic review and meta-analysis. *Clinical Psychology Review*, *31*(6),1032–1040.

R Core Team (2022). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Reed, D. E., 2nd, Fischer, I. C., Williams, R. M., Na, P. J., & Pietrzak, R. H. (2024). Co-occurring Chronic Pain and PTSD Among US Military Veterans: Prevalence, Correlates,

and Functioning. *Journal of General Internal Medicine*, *39*(11), 2009–2016. https://doi.org/10.1007/s11606-024-08803-w

Reed, D. E., 2nd, Stump, T. E., Monahan, P. O., & Kroenke, K. (2024). Comparable minimally important differences and responsiveness of Brief Pain Inventory and PEG Pain Scales across 6 Trials. *The Journal of Pain, 25*(1), 142–152. https://doi.org/10.1016/j.jpain.2023.07.028

Ribeiro, L., Atchley, R. M., & Oken, B. S. (2018). Adherence to Practice of Mindfulness in Novice Meditators: Practices Chosen, Amount of Time Practiced, and Long-Term Effects Following a Mindfulness-Based Intervention. *Mindfulness*, *9*(2), 401–411. https://doi.org/10.1007/s12671-017-0781-3

Rosenzweig, S., Greeson, J.M., Reibel, D.K., Green, J.S., Jasser, S.A., Beasley, D. (2010). Mindfulness-based stress reduction for chronic pain conditions: variation in treatment outcomes and role of home meditation practice. *Journal of Psychosomatic Research*, *68*(1), 29-36. doi: 10.1016/j.jpsychores.2009.03.010. PMID: 20004298.

Rikard, S. M., Strahan, A.E., Schmit, K.M., Guy, G.P. Jr. (2023). Chronic Pain Among Adults — United States, 2019–2021. *Morbidity and Mortality Weekly Report*, *72*, 379–385. DOI: http://dx.doi.org/10.15585/mmwr.mm7215a1.

Ruan, H., Pocock, I. T., & Ruan, H. (2023). "You Just Have to Stick with the Practice": A Long-Term Weekly Mindfulness Group at the VA. *Group*, *47*(12), 91-114.

Schneider, C. B., Pilhatsch, M., Rifati, M., Jost, W. H., Wodarz, F., Ebersbach, G., . . . Storch, A. (2010). Utility of the WHO-Five Well-being Index as a screening tool for depression in Parkinson's disease. *Movement Disorders*, *25*, 777-783.

Scorsone, K.L., Frank, J.W. (2024). Exploring Veterans' Experiences Accessing Chronic Pain Treatment in the VA Community Care Network. *Journal of General Internal Medicine, 39,* 3190–3195. https://doi.org/10.1007/s11606-024-09023-y

Smith, T.J., Hillner, B.E. (2019). The Cost of Pain. *JAMA Network Open, 2*(4), e191532. doi:10.1001/jamanetworkopen.2019.1532

Strohmaier, S. & Goldberg, S. B. (in press). Longitudinal increases in mindfulness practice quality are associated with changes in psychological outcomes and not vice versa: A brief report. *Current Psychology.*

Strohmaier, S., Jones, F. W., & Cane, J. E. (2021). Effects of Length of Mindfulness Practice on Mindfulness, Depression, Anxiety, and Stress: A Randomized Controlled Experiment. *Mindfulness*, *12*(1), 198–214. https://doi.org/10.1007/s12671-020-01512-5

Vadivelu, N., Kai, A.M., Kodumudi, G., Babayan, K., Fontes, M., Burg, M.M. (2017). Pain and Psychology-A Reciprocal Relationship. *Ochsner Journal*, *17*(2),173-180. PMID: 28638291; PMCID: PMC5472077.

Wachholtz, A., Vohra, R., & Metzger, A. (2019). A reanalysis of a randomized trial on meditation for migraine headaches: Distraction is not enough but meditation takes time. *Complementary Therapies in Medicine*, *46*, 136–143. https://doi.org/10.1016/j.ctim.2019.08.011

Warr, P., Banks, M., & Ullah, P. (1985). The experience of unemployment among black and white urban teenagers. *British Journal of Psychology, 76*, 75-87.

Xie, Q., Dyer, R. L., Lam, S. U., Frye, C., Dahl, C. J., Quanbeck, A., ... & Goldberg, S. B. (2024). Understanding the implementation of informal meditation practice in a smartphone-based intervention: A qualitative analysis. *Mindfulness*, *15*, 479–490.

Zeidan, F., Adler-Neal, A. L., Wells, R. E., Stagnaro, E., May, L. M., Eisenach, J. C., McHaffie, J. G., & Coghill, R. C. (2016). Mindfulness-Meditation-Based Pain Relief Is Not Mediated by Endogenous Opioids. *The Journal of Neuroscience*, *36*(11), 3391–3397. https://doi.org/10.1523/JNEUROSCI.4328-15.2016

Zgierska, A. E., Edwards, R. R., Barrett, B., Burzinski, C. A., Jamison, R. N., Nakamura, Y., Henningfield, M. F., Tuan, W. J., Shen, C., Sehgal, N., Lennon, R. P., Dong, H., Chinchilli, V. M., Liu, Y., Turnquist, A., Schiefelbein, A. R., Jacobs, E. A., Veasley, C., Cowan, P., & Garland, E. L. (2025). Mindfulness vs Cognitive Behavioral Therapy for Chronic Low Back Pain Treated With Opioids: A Randomized Clinical Trial. *JAMA Network Open*, 8(4), e253204. https://doi.org/10.1001/jamanetworkopen.2025.3204

Table 1. Mindfulness Training Program Clinical Protocol

Phase	Length	Sessions	Measures
Foundation Phase	Two months	Weekly individual sessions (60minutes)	First session, 1 month, & 2 month: Chronic Pain Acceptance Questionnaire-8 (CPAQ-8) World Health Organization-5 Well-being Index (WHO-5) World Health Organization Quality of Life-Brief Version (WHOQOL-BREF) 1 & 2
Intermediate Phase	Two months	Biweekly individual sessions (30 or 60 minutes) Weekly mindfulness group	None
Continuing Care Phase	Ongoing	Monthly/bimonthly individual sessions (30 minutes) Weekly mindfulness group	None

Table 2. Session Structure

Component	Length	Measures
Check-in	2-10 minutes	Formal practice time Mindfulness Practice Quality (PQM) Pain, Enjoyment of Life and General Activity (PEG) Scale—Interference with Enjoyment of Life Item (Outcome measures during 1st session, 1st month, and 2nd month of Foundation Phase)
Open Discussion	10-15 minutes	
First Practice Set	7-10 minutes	
Discussion	10 minutes	
Second Practice Set	7-10 minutes	
Discussion	10 minutes	
Third Practice Set	3-5 minutes	

Note: Reflects structure for both group and individual sessions.

Table 3. Sample demographic characteristics at baseline

Variable	*n* (%)
Total sample at baseline	82 (100%)
Gender	
Female	27 (32.9%)
Male	55 (67.1%)
Age	50.35 (13.5)
Race/Ethnicity	
African American or Black	12 (14.6%)
Asian	7 (8.5%)
Latinx	1 (1.2%)
Middle Eastern	1 (1.2%)
Multiracial	4 (4.9%)
White	56 (68.3%)
Declined	1 (1.2%)

Note: Participants were asked to self-identify race and ethnicity.

Table 4. Pain acceptance, subjective well-being, and quality of life at baseline, 1-month follow-up, and 2-month follow-up

Variable	Baseline (n = 82) M (SD)	1-month (n = 56) M (SD)	2-month (n = 45) M (SD)
CPAQ-8	20.91 (8.03)	22.79 (7.41)	22.76 (7.63)
WHO-5	2.10 (0.96)	2.52 (1.01)	2.61 (0.97)
WHOQOL-BREF			
Item 1: "How would you rate your Quality of Life?"	3.11 (1.15)	3.18 (0.97)	3.24 (0.93)
Item 2: "How satisfied are you with your health?"	2.23 (0.91)	2.62 (1.04)	2.71 (0.97)

Note: CPAQ-8 = Chronic Pain Acceptance Questionnaire, 8-item; WHO-5 = World Health Organization Wellbeing Index; WHOQOL-BREF = World Health Organization Quality of Life-Brief Version. The CPAQ-8 total ranges from 0 to 48, with higher scores indicating greater acceptance. The WHO-5 total ranges from 0 to 5, with higher scores indicating higher wellbeing. The WHOQOL-BREF answers range from 1 (*very poor*) to 5 (*very good*).

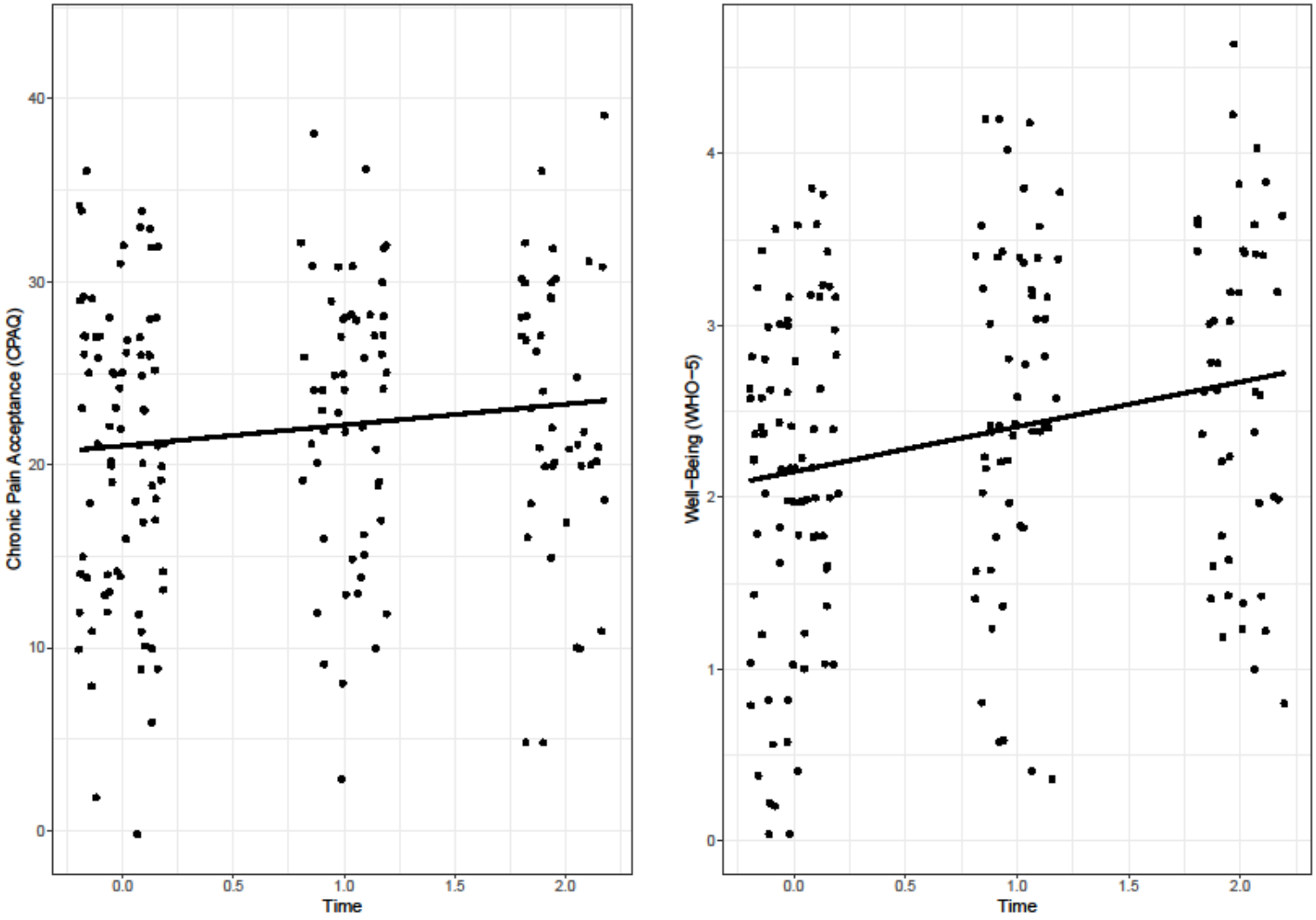
Supplemental Table 1. Sensitivity analyses examining change in mindfulness practice quality at 30 and 60 days using linear, quadratic, and cubic models

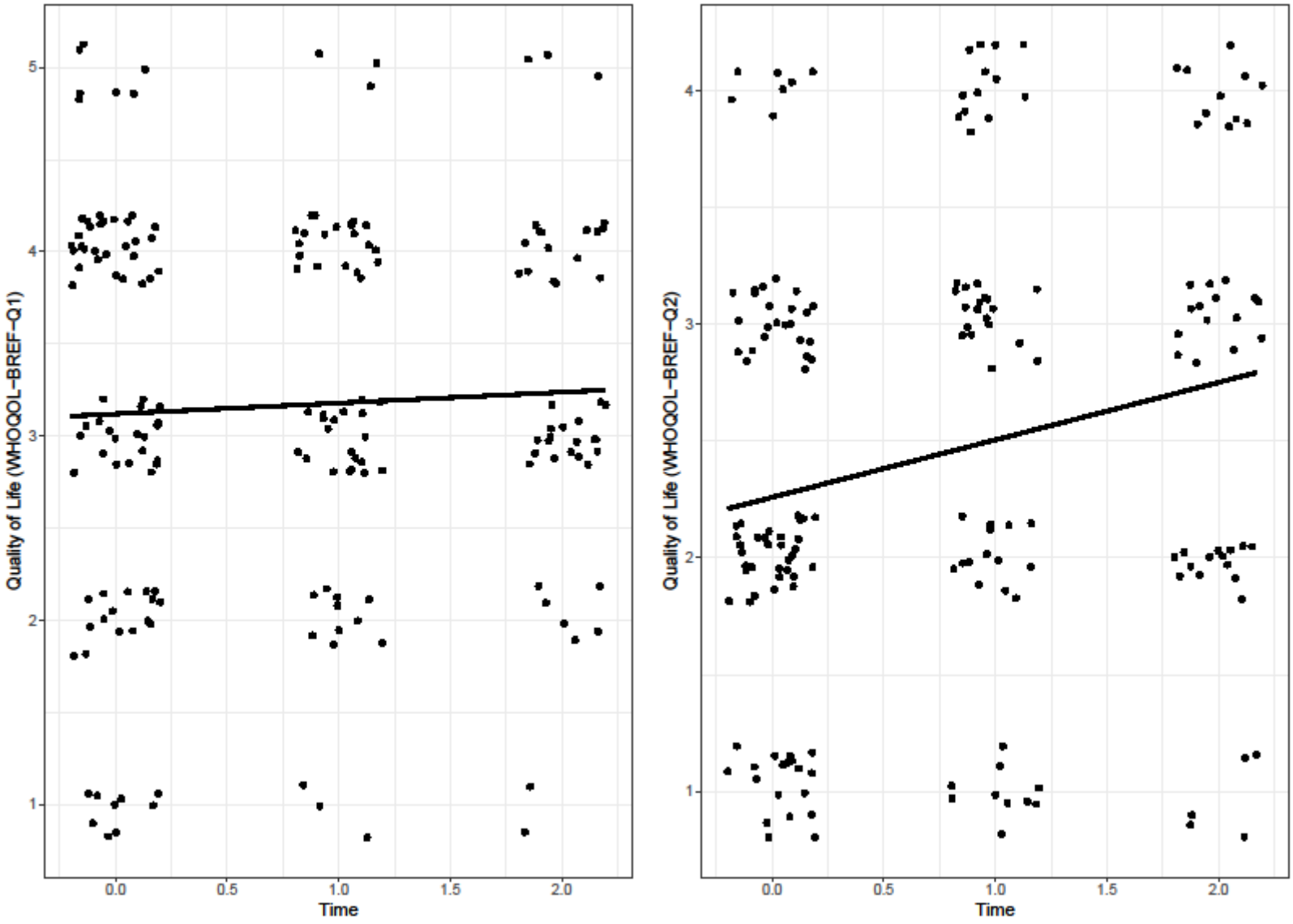
Model	*B*	*SE*	*p*
30-day follow-up			
Linear	0.05	0.01	.001
Quadratic			
Time	0.012	0.048	.816
$Time^2$	0.0011	0.0015	.475
Cubic			
Time	-0.13	0.11	.233
$Time^2$	0.013	0.0081	.116
$Time^3$	-0.00026	0.00018	.142
60-day follow-up			
Linear	0.028	0.0059	<.001
Quadratic			
Time	0.040	0.019	.036
$Time^2$	-0.00020	0.00031	.515
Cubic			
Time	0.035	0.044	.424
$Time^2$	0.000016	0.0017	.993
$Time^3$	-0.0000021	0.000019	.914

Supplemental Table 2. Formal practice time as a moderator of changes in practice quality

Predictor	*B*	*SE*	*p*
30-day follow-up			
Time (day)	0.046	0.018	.0113
Formal practice	0.050	0.046	.289
Time x formal practice	-0.00022	0.0013	.869
60-day follow-up			
Time (day)	-0.0073	0.0097	.453
Formal practice	0.033	0.022	.151
Time x formal practice	-0.000012	0.00047	.980

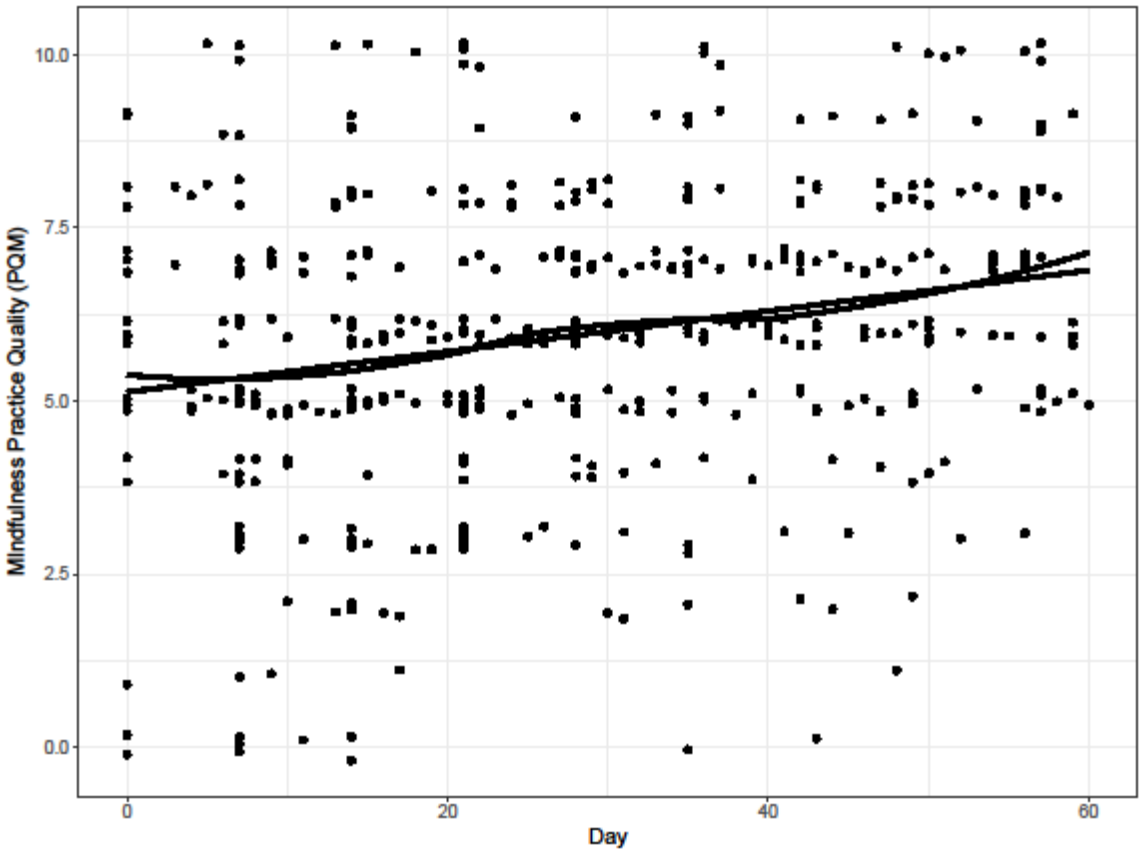
Figure 1. Changes in pain acceptance (CPAQ), subjective well-being (WHO-5), quality of life (WHOQOL-BREF-Q1), and satisfaction with health (WHOQOL-BREF-Q2) from baseline to 1-month and 2-month follow-ups.





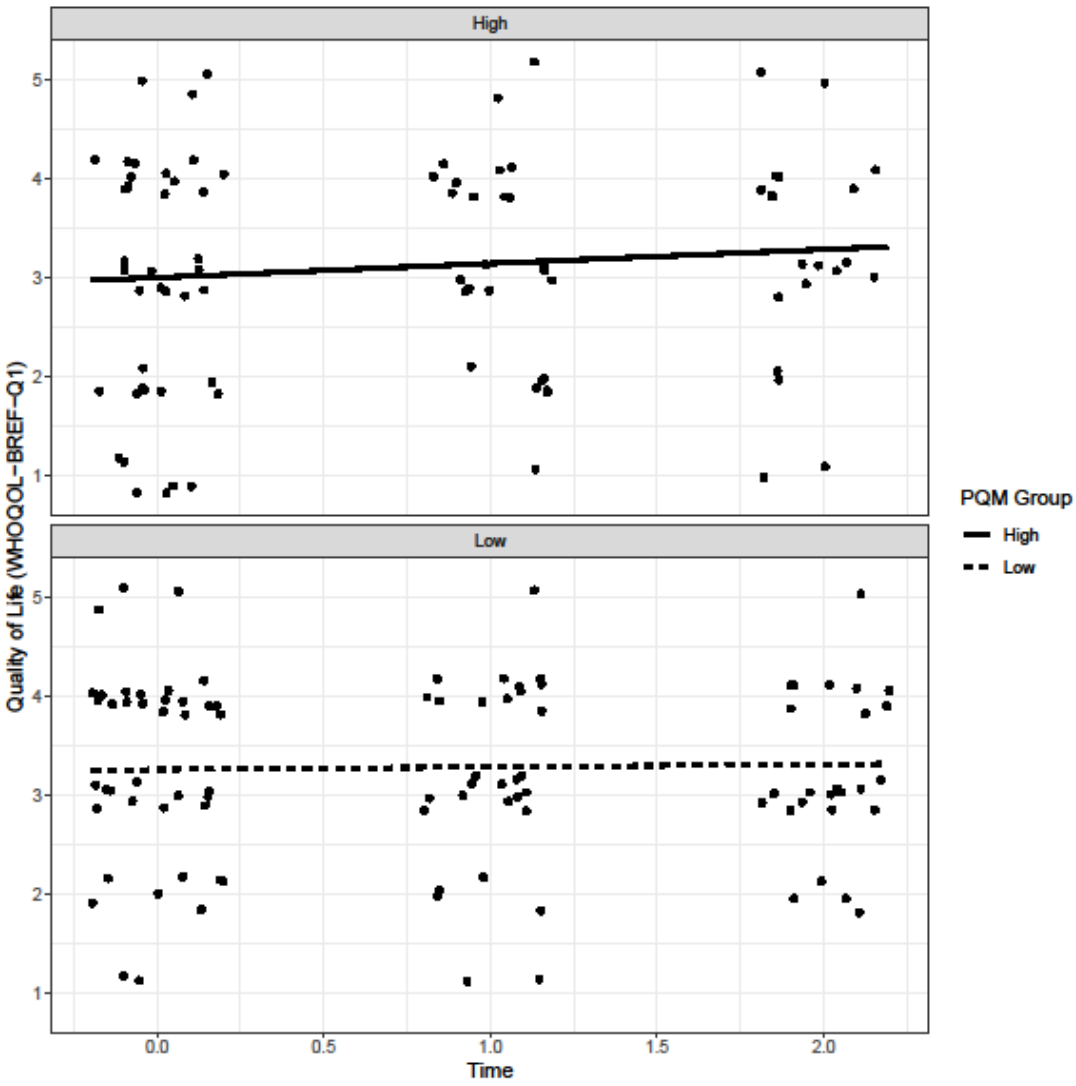
Note: Time 0 = baseline, 1 = 1-month follow-up, and 2 = 2-month follow-up.

Figure 2. Mindfulness practice quality (PQM) improved through 2-month follow-up.



Note: Figure displays linear regression line and loess curve.

Figure 3. Individuals who reported steeper increases in practice quality (PQM) reported greater improves in quality of life (WHOBREF Q1) from baseline to 2-month follow-up.



Note: PQM Group defined based on median split of random slopes reflecting changes in PQM scores over time. Group defined as "High" had increases in PQM scores at or above the median. Models were run treating changes in PQM scores over time (i.e., random slopes) continuously. Median split is displayed for illustrative purposes only.