Received: 4 August 2023 | Accepted: 1 December 2023

DOI: 10.1111/aphw.12518

ORIGINAL ARTICLE

APPLIED PSYCHOLOGY: Health and Well-Being IAAP

The shape of the change: Cumulative and incremental changes in daily mood during mobile-app-supported mindfulness training

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Funding information
Polish National Science Centre, Grant/Award Number: 2017/26/A/HS6/00647

Abstract

Understanding of the exact trajectories of mood improvements during mindfulness practice helps to optimize mindfulness-based interventions. The Mindfulness-to-Meaning model expects mood improvements to be linear, incremental, and cumulative. Our findings align with this expectation. We used multilevel growth curve models to analyze daily changes in positive mood reported by 190 Polish participants during 42 days of a mobile-app-supported, mindfulness-based intervention. The daily positive mood increased among 83.68% of participants. Participants who started the training reported worse mood improved more and faster than participants with better mood at the baseline. Dispositional mindfulness and narcissism – individual difference variables associated with high vs. low emotion regulation ability, respectively – were not associated with mood improvement trajectories. A small group of participants (16.32%) showed a steady decline in positive mood during the intervention. The results underscore

Funding details This work was supported by the Polish National Science Centre advanced research grant Maestro [2017/26/A/HS6/00647] awarded to Agnieszka Golec de Zavala.

the importance of a more comprehensive understanding of individual variability in benefiting from mindfulness-based interventions.

KEYWORDS

adverse consequences, daily mood changes, mindfulness, multilevel growth curve modeling, well-being

INTRODUCTION

Refined management of positive and prosocial emotions (e.g., Lindsay et al., 2018; Singer & Engert, 2019), positive reappraisal, and broadened self-awareness (Garland & Fredrickson, 2019; Hanley et al., 2021) underlie the positive effects of mindfulness practice on psychological well-being. However, the exact trajectories of mood improvements during mindfulness practice are understudied (Krick et al., 2021; Snippe et al., 2017). The need for dense temporal sampling of psychological data during mindfulness-based interventions has been recently emphasized by research suggesting that the effects of those interventions may not be universally the same (Goldberg et al., 2022), and some participants may experience long-lasting adverse effects of mindfulness practice (Britton et al., 2021).

To address this need, we examine trajectories of change in daily mood during a 6-week, mobile-app-supported mindfulness-based intervention. A randomized-controlled-trial study among 219 Polish adults showed that, on average, this intervention improved participants prosociality and well-being (Golec de Zavala, Ziegler, Keenan, Ciesielski, Mazurkiewicz, & Wahl, 2023; Golec de Zavala, Ziegler, Keenan, Ciesielski, Mazurkiewicz, Wahl, Nalberczak-Skora, & Sedikides, 2023). The present analyses use previously unexplored data from this study: mood self-reports collected daily before and after each guided mindfulness session. They offer a novel, fine-grained picture of the daily mood improvements of each participant during the intervention.

CUMULATIVE CHANGES DURING MINDFULNESS PRACTICE

Cultivating mindfulness – "the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment" (Kabat-Zinn, 2003, p. 144) – was proposed as one of the ways to manage the impending global mental health crisis (Creswell, 2017; Goldberg et al., 2022; Kabat-Zinn, 2019). Initially used to support stress management in clinical populations (e.g., mindfulness-based stress reduction [MBSR]; Kabat-Zinn, 2003), mindfulness-based interventions evolved as a tool to tackle mental health issues in clinical (e.g., mindfulness-based cognitive therapy [MBCT]; Segal et al., 2013) and sub-clinical populations. They reduce symptoms of anxiety and depression and improve well-being and quality of life (Kuyken et al., 2016). In non-clinical populations, they support stress reduction (Khoury et al., 2015) and the ability to regulate emotions (e.g., Goldberg et al., 2022).

The Mindfulness-to-Meaning model (Garland et al., 2015; Garland & Fredrickson, 2019) proposes a linear process of how the skills acquired during mindfulness practices gradually

develop to produce cumulative changes in emotional regulation and well-being. The model postulates causal links between the psychological processes instigated by mindfulness practice. Practicing mindfulness increases focus, broadness, and flexibility of attention. The new skills in attention management help to postpone immediate judgment and emotional reactions to experience. In consequence, practitioners develop the ability to observe their experience as it unfolds from a third-person perspective. As they exercise this ability, practitioners gradually acquire insights into their own maladaptive reaction patterns (Kropp & Sedlmeier, 2019). They are enabled to constructively reappraise the experience in an adaptive way. The detached perspective, mindful positive reappraisal, and accepting attitude toward the experience result in improved well-being (Garland et al., 2015; Hanley et al., 2021; Lindsay et al., 2018; Verhaeghen, 2019).

The Mindfulness-to-Meaning model suggests cumulative, gradual, and linear improvements in well-being as a result of mindfulness practice. This suggestion is largely supported by the findings of the few studies that examined daily changes in indices of well-being (e.g., positive mood and emotional resistance). The findings align with the proposition that the trajectory of the changes in positive mood during the mindfulness intervention is cumulative and linear (Snippe et al., 2017). However, they also suggest that trajectories of change may differ between participants, with some participants showing stronger increases in the beginning in comparison to the end of the intervention (Krick et al., 2021).

A more in-depth understanding of how the effects of mindfulness-based interventions unfold among different participants may help to optimize the interventions. There are reasons to believe that participants who start the training in a worse mood may benefit faster but need more time to stabilize, whereas participants who start in a better mood may benefit from shorter interventions (Krick et al., 2021; Snippe et al., 2017). There are also reasons to expect that some participants may not benefit from mindfulness interventions or even suffer gradual accumulation of its adverse effects (Britton et al., 2021). By examining which trajectories of change occur during the mindfulness training, we may provide a more comprehensive understanding of who and how may benefit from mindfulness practice.

PREDISPOSITIONS TO BENEFIT FROM MINDFULNESS TRAINING

It is generally unclear which individual characteristics boost or restrict the effectiveness and dynamics of improvements during well-being supporting interventions (Krick et al., 2021; Lyubomirsky & Layous, 2013). However, initial studies suggest that pre-to post-intervention improvements in well-being due to mindfulness-based interventions are larger among participants with more developed self-care practices and more positive attitudes toward mindfulness as well as among more neurotic and open-minded participants (Krick & Felfe, 2020). Studies using dense data sampling indicate that participants with better self-care and lower stress vulnerability benefit the most and the fastest from the mindfulness-based intervention, whereas lower dedication to self-care and higher vulnerability to stress are related to more modest and slower improvements (Krick et al., 2021). Based on this evidence, we explored whether two individual characteristics predict the trajectories of positive mood change during the mindfulness-based intervention: dispositional mindfulness and individual narcissism.

Dispositional mindfulness is an individual difference variable associated with psychological well-being (Tomlinson et al., 2018), the increase in well-being over time (Prieto-Fidalgo et al., 2022), and better self-care (Slonim et al., 2015). Thus, it is reasonable to assume that

people with higher dispositional mindfulness at the baseline may enter the training with a higher positive mood, and for them, the increase in positive mood may not be as steep as for people with lower dispositional mindfulness. Moreover, people with higher dispositional mindfulness may have a positive attitude toward the training, which may allow them to benefit more overall and end the training with a more positive mood than people with lower dispositional mindfulness.

Narcissism is an individual difference variable associated with poor emotion regulation. It is characterized by defensive exaggeration of self-importance, interpersonal antagonism, and low prosociality (e.g., Sedikides, 2021). Grandiose narcissism (agentic, entitled, self-aggrandizing, and exploitative) is thought to be more adaptive than vulnerable (hypersensitive, frustrated, and detached) narcissism. Grandiose narcissism is associated with high self-esteem and well-being. Vulnerable narcissism is associated with low self-esteem, frustration, and neuroticism (Krizan & Herlache, 2018). Nevertheless, a mindfulness intervention study showed that the intervention was effective on low but not on high levels of grandiose narcissism (Ridderinkhof et al., 2017). Correlational studies show that grandiose narcissism is negatively associated with dispositional mindfulness (Fatfouta & Heinze, 2022; Van Doesum et al., 2020). This suggests that while mindfulness practice may be beneficial to improve emotional regulation among narcissists, narcissism overall may impair the effectiveness of the mindfulness-based intervention. Thus, we examined whether narcissism, in its grandiose and vulnerable presentations, is associated with trajectories of positive mood change during the mindfulness training.

OVERVIEW

To analyze trajectories of change, we used data from daily general mood assessments collected during 42 days of mobile-application-supported, audio-guided, mindfulness-based training. We examined the overall shape of change in daily mood during the intervention and individual variations in the change. We also explored whether there are individual differences in dispositional mindfulness and narcissism between participants who show different trajectories of changes during the training. The daily mood scores were collected from participants in a pre-registered randomized-controlled-trial study (Golec de Zavala, Ziegler, Keenan, Ciesielski, Mazurkiewicz, & Wahl, 2023; Golec de Zavala, Ziegler, Keenan, Ciesielski, Mazurkiewicz, Wahl, Nalberczak-Skora, & Sedikides, 2023). The measurements of dispositional mindfulness and narcissism used in the present analyses overlap with previous pre-registered analyses. Nevertheless, the present follow-up analyses are novel and exploratory and aim at answering a different research question than the pre-registered hypotheses. The daily mood data are analyzed for the first time.

ANALYTICAL STRATEGY

To analyze the trajectory of the change in daily mood within participants over the course of the training, we applied multilevel growth curve modeling, which considers the nested structure of longitudinal data where observations (e.g., daily) of the dependent variable (level 1) are nested within individual participants (level 2, Hox et al., 2017). We conducted all analyses separately for the continuous outcome variables for mood before the daily session (Mood A), mood after the session (Mood B), and for the difference between Mood A and Mood B (Mood Difference).

While the mood before the daily session (Mood A) represents cumulative change over time, the mood after the session (Mood B) represents the incremental increase in mood over time due to participants engaging in each session of guided practice. Increases in both indices suggest that mood improves steadily during the training. The difference between pre- and post-assessments for each session (Mood Difference) is another index tapping the incremental daily change. It should steadily decrease to indicate that the training works to stabilize positive mood improved during the training.

First, we specified Random-Intercept-Only Models to quantify the average mood levels. Based on these models, we calculated intra-class correlation coefficients (ICCs), which allowed us to quantify the proportion of variance in positive mood explained by interindividual differences. Random-Intercept-Only Models do not include any predictors but individual intercepts (starting points), which are allowed to vary between participants. Second, we applied Homogeneous Growth Curve Models (i.e., with one average slope per model) to test whether the day/week of the training significantly ($p < 0.01$) predicted mood in a positive, linear way. To examine whether and how individual trajectories of mood changes differ and how mood levels at the beginning of the training and mood changes throughout the training are correlated, we used Heterogeneous Growth Curve Models including random slopes for the level 1 predictor (day/week), that is, allowing individual trajectories.

We identified two groups of participants: those whose mood increased during the training and those whose mood decreased. To investigate whether the included individual difference variables were related to the mood increase vs decrease, we conducted *t*-tests for independent samples to compare the two groups with respect to mean levels of dispositional mindfulness as well as grandiose and vulnerable narcissism assessed at the baseline. Next, we included those individual difference variables as level 2 covariates in our Heterogeneous Growth Models to investigate whether they moderate the changes in daily mood throughout the training. Specifically, we included cross-level interactions between each level 2 predictor and the level 1 predictor (day/week) while controlling for the other level 2 covariates. Before including the individual variables as level 2 predictors in our Multilevel Growth Curve Models we grand-mean centered them, apart from the training group variable, which was dichotomous.

To control the increased risk of type I errors due to multiple testing, we applied Bonferroni correction resulting in an alpha level of .016 for *t*-tests and .0125 for Heterogeneous Growth Curve Models including level 2 predictors. When adding effects such as random slopes or cross-level interactions, we used chi-square difference tests to compare the fit of the extended models. We only pursued the extension of the models if the improved model converged, and the fit was significantly improved ($p < .01$). All analyses were conducted in R version 4.2.1 (R Core Team, 2020). The Multilevel Growth Curve Model analyses were performed using the packages lme4 and lmerTest (Bates et al., 2015).

METHOD

Participants

Data consisted of 42 daily observations of mood (level 1) nested within 190 participants (level 2) who took part in a mobile-app-supported mindfulness training. The data were collected in a convenience sample of 219 Polish adults, 168 women, and 48 men (three did not disclose the gender) whose ages ranged between 18 and 62 ($M = 28.15$, $SD = 8.15$). Data from

29 participants who provided mood assessments with no variance (provided more than 38 identical mood assessments) were removed. The final sample consisted of 190 participants, 149 women, and 39 men (two did not disclose their gender). The age ranged between 18 and 62 ($M = 27.89$, $SD = 8.07$). Participants were recruited via social media and university mailing lists during the COVID-19 pandemic (for details and the CONSORT diagram, see Golec de Zavala, Ziegler, Keenan, Ciesielski, Mazurkiewicz, & Wahl, 2023).

The study had a randomized controlled trial, mixed design with a two-level within factor (pretest vs. posttest measurements) and a two-level between factor (mindfulness condition: waiting list vs. training; Golec de Zavala, Ziegler, Keenan, Ciesielski, Mazurkiewicz, & Wahl, 2023; Golec de Zavala, Ziegler, Keenan, Ciesielski, Mazurkiewicz, Wahl, Nalberczak-Skora, & Sedikides, 2023). The data analyzed here were collected daily to support the main, preregistered analyses. The original sample size was estimated using G*Power for the mixed ANOVA with within-between interaction, two groups, and two measurement points (Faul et al. 2007). We conservatively assumed a medium effect size of the training, $f = 0.15$, based on the smallest effect size of the effect of mindfulness practice on well-being and we set a minimum correlation coefficient between the initial and final measurement, $r = .05$, following results of previous studies (de Vibe et al., 2018; Ivtzan et al., 2016). The required sample size was 110. We oversampled to correct for data attrition. Although the sample size estimation was performed for different analyses, the sample of $N = 190$ provided a sufficient power base for the multilevel analyses presented here. Simulation studies indicate that L2/L1 ratio of 190/42 is sufficient to obtain unbiased and accurate estimates of regression coefficients, variances, and their standard errors assuming power of .80 and medium effect sizes (Arend & Schäfer, 2019; Maas & Hox, 2005). We estimated a sample size necessary to compare groups of participants who improved vs. declined during the training using G*Power and assuming that the data are analyzed by the independent *t*-test. For power of .80 and the corrected alpha level of .017, the sufficient sample size was 170.

Procedure

First, we collected demographic data and baseline measurements of individual difference variables. Next, participants met online with a monitoring experimenter who instructed them on the installation and usage of the mindfulness training app. During one-to-one meetings, participants were instructed to practice daily, in the morning, in a quiet place where they could sit down undisturbed for half an hour. To practice, participants logged into the mobile app, read the short introduction describing the skills to be practiced during the session, and followed recorded guidance to practice those skills. The content of the training and the analyses testing its feasibility and effectiveness are described in detail in a separate publication (Golec de Zavala, Ziegler, Keenan, Ciesielski, Mazurkiewicz, Wahl, Nalberczak-Skora, & Sedikides, 2023).

The training consists of 42 recorded guided sessions following a progressive sequence from simpler to more complex tasks. The sessions last about 17 minutes on average. Participants can follow only one daily session at a time. The new sessions were unlocked at 5.00 am each morning, and participants were prompted to practice if the app did not register any activity by 11 am each day. Week 1 sessions exercise the ability to focus attention on breath and bodily experiences which help anchor practitioners in the physical aspect of experience. Building on this ability, the training progresses to the "body scanning" practice that develops attention flexibility. Next, the training focuses on agentic skills of intentionally directing, broadening, or narrowing attention to the physical and mental experiences. The training then progresses to

practicing a third-person or disengaged observer approach toward the unfolding experience. Finally, participants learn to acknowledge, witness, and address their emotions with understanding, kindness, and gratitude without the necessity of immediate reaction. Through repetition of exercises and experiences during the sessions, the training facilitates learning and more effortless and automatic adaptive reappraisal.

We used several retention strategies to ensure continuous participation. First, participants signed an informed consent that explained the rules of their participation and payment. They were informed the amount of money they could make participating in the study depended on the number of sessions they actively followed (in the end everyone was paid the same amount of money). In addition, the app registered whether participants logged in and how long they spent following each session. It also logged their response to the control question based on the content of the session. The app allowed participants to monitor how much money each finished session added to the final sum they were to be paid in exchange of their participation. The app also reminded participants about each session in the evening prior and in the morning of the day of the session. Finally, using the same app, experimenters were able to monitor participants' daily progress, checking whether they logged into the app, how long they spent using it, and whether they answered the control questions correctly. Participants who did not participate in the training for 24 hours were contacted by the experimenter with a reminder to practice.

Participants took part in the training in two groups during 12 weeks: the training group ($n = 103$) took part in the training during the first 6 weeks of the study and the waiting list group ($n = 116$) participated in the training during the second 6 weeks of the study. As the group did not moderate the results of the present analyses (see Table 1), the data from both groups were collapsed.

Measurements

Daily Mood was assessed before and after each session on the 5-point graphic scale from 1 (labeled "negative" and represented by a sad emoticon) to 5 (labeled "positive" and represented by a happy emoticon).

Individual difference variables were measured at the beginning of the training. Participants provided responses using a 1 ("*definitely disagree*") to 7 ("*definitely agree*") scale. *Dispositional Mindfulness* was measured by the Five Facet Mindfulness Questionnaire (FFMQ; Bohlmeijer et al., 2011). All items were averaged so the higher scores express higher levels of dispositional mindfulness, $\alpha = .87$; $M = 4.24$; $SD = .76$. *Narcissism* was assessed in two forms: grandiose and vulnerable. Grandiose narcissism was assessed with the 16-item Narcissistic Personality Inventory (Ames et al., 2006; e.g., "I know that I am good because everybody keeps telling me so"), $\alpha = .80$; $M = 3.77$; $SD = .80$. Vulnerable narcissism was assessed with a 10 item the Hypersensitive Narcissism Scale (Hendin & Cheek, 1997; e.g., "I can become entirely absorbed in thinking about my personal affairs, my health, my cares or my relations to others."), $\alpha = .72$; $M = 3.89$; $SD = .79$.

RESULTS

Cumulative mood improvement during the mindfulness training

First, we specified Random-Intercept-Only Models for the three mood variables to quantify the average mood levels and to assess between-participant variation in mood by calculating

TABLE 1 Fixed effect estimates from heterogeneous growth curve models including cross-level interactions for Mood A, Mood B, and Mood Difference.

	Mood A			Mood B			Mood Difference		
Variables	**Estimate**	**SE**	***p***	**Estimate**	**SE**	***p***	**Estimate**	**SE**	***p***
Model 1: Including a cross-level-interaction between week of training (level 1) and grandiose narcissism (level 2)									
Intercept	3.280	0.034	< .001	3.682	0.037	< .001	0.399	0.031	< .001
Week	0.054	0.007	< .001	0.026	0.007	< .001	−0.027	0.005	< .001
Grandiose narcissism	−0.003	0.044	.948	0.011	0.048	.804	0.014	0.040	.729
Vulnerable narcissism	−0.056	0.047	.238	−0.085	0.051	.102	−0.022	0.038	.564
Dispositional mindfulness	0.184	0.049	< .001	0.188	0.053	< .001	−0.013	0.039	.738
Week: Grandiose narcissism	0.003	0.009	.772	0.015	0.009	.097	0.013	0.007	.060
Model 2: Including a cross-level-interaction between week of training (level 1) and vulnerable narcissism (level 2)									
Intercept	3.28	0.034	< .001	3.682	0.037	< .001	0.399	0.031	< .001
Week	0.054	0.007	< .001	0.026	0.007	< .001	−0.027	0.005	< .001
Grandiose narcissism	−0.056	0.051	.269	−0.113	0.055	.041	−0.069	0.045	.126
Vulnerable narcissism	0.002	0.04	.951	0.045	0.043	.305	0.058	0.032	.073
Dispositional mindfulness	0.184	0.049	< .001	0.188	0.053	< .001	−0.013	0.039	.739
Week: Vulnerable narcissism	0	0.009	.988	0.013	0.009	.149	0.013	0.007	.047
Model 3: Including a cross-level-interaction between week of training (level 1) and dispositional mindfulness (level 2)									
Intercept	3.280	0.034	< .001	3.682	0.037	< .001	0.399	0.032	< .001
Week	0.054	0.007	< .001	0.026	0.007	< .001	−0.027	0.005	< .001
Grandiose narcissism	0.182	0.052	< .001	0.217	0.057	< .001	0.039	0.046	.398
Vulnerable narcissism	0.002	0.040	.951	0.044	0.043	.306	0.058	0.032	.073
Dispositional mindfulness	−0.056	0.047	.238	−0.084	0.051	.102	−0.021	0.038	.564
Week: Mindfulness	0	0.009	.946	−0.013	0.009	.164	−0.015	0.007	.033

TABLE 1 (Continued)

	Mood A			Mood B			Mood Difference		
Variables	**Estimate**	**SE**	***p***	**Estimate**	**SE**	***p***	**Estimate**	**SE**	***p***
Model 4: Including a cross-level-interaction between week of training (level 1) and group (level 2)									
Intercept	3.317	0.050	< .001	3.704	0.056	< .001	0.382	0.043	< .001
Week	0.053	0.011	< .001	0.020	0.010	.057	−0.032	0.008	< .001
Group	−0.074	0.071	.302	−0.045	0.079	.573	0.034	0.061	.578
Week: Group	0.003	0.014	.857	0.014	0.014	.340	0.010	0.011	.371

Note: The level-2 variables grandiose narcissism, vulnerable narcissism, and dispositional mindfulness were grand-mean centered. The variable week results from rescaling the initial day variable and represents the week of the training such that 1 represents 1 week. The group variable refers to the group defined by the order in which participants received the training: first 6 weeks (the training group) or second 6 weeks (the waiting group). The reference category for the group was the waiting-list group.

the intraclass correlation coefficients (ICCs). The average mood before sessions (Mood A) was 3.4463 (t[188.93] = 102.9, $p < .001$), the average mood after sessions (Mood B) was 3.76199 (t[189.02] = 104.6, $p < .001$), and the average difference between moods was 0.31556 (t[189.31] = 12.85, $p < .001$). The intraclass correlation coefficient (ICC) indicates a substantial amount of within-participant variation across mood scores. They indicate that 26.6% of the variance in Mood A, 34.6% in Mood B, and 24.2% in Mood Difference can be explained by differences between individuals.

To determine whether there was a linear trend in the change in mood indices, we applied Homogeneous Growth Curve Models. We included training day/week as a predictor assessing its fixed effect (i.e., average slope) across participants. For all three mood indices, chi-square tests showed that the Homogeneous Growth Curve Models fit the data better than the Random-Intercept-Only Models (for Mood A: χ^2 (1) = 123.31, p < .001, for Mood B: χ^2 (1) = 33.322, $p < .001$, for Mood Differences χ^2 (1) = 50.69, $p < .001$). As the Homogeneous Growth Curve Models included linear slopes, the improved fits indicate that there are linear trends in the change across all mood indices.

The Homogeneous Growth Curve Models suggested that the initial mean of Mood A was 3.28 (t[270.50] = 89.5, $p < .001$). Training day/week had a significant positive effect of 0.054327 points per week (t[7420.34] = 11.15, $p < .001$) on Mood A. Individual mood before sessions increased by an average of 0.054327 units per week of the training. The initial mean of Mood B was 3.68 (t[246.97] = 95.79, $p < .001$). The training day/week had a significant positive effect of 0.025780 points per week (t[7238.83] = 5.779, $p < .001$). Thus, individual mood after the session increased by an average of 0.025780 units per week of the training. The initial mean of the Mood Differences was 0.40 (t[286.33] = 14.682, $p < .001$). Training day/week had a significant negative effect of 0.02753 units per week (t[7240.21] = −7.132, $p < .001$). This means that the difference between initial mood and mood after the session decreased by an average of 0.02753 units per week of the training.

Improvements in mood depending on the initial mood

Next, we used Heterogeneous Growth Curve Models with random slopes to assess whether there was a between-participant variation in mood changes during the training. We allowed the slope of the day/week variable to vary between participants. The comparative test showed that the Heterogeneous Growth Curve Model for Mood A fit the data significantly better than the Homogeneous Growth Curve Model (χ^2 [2] = 89.06, $p < .001$), suggesting between-participant variation in changes of mood A during the training. The estimated initial mean of Mood A on day 1 of the training was 3.28 (t[188.70] = 91.77, $p < .001$) and the average change per week was 0.05 (t[189.10] = 7.562, $p < .001$), which is similar to the results obtained from the Homogeneous Growth Curve Models. The estimated slope variance in the Heterogeneous Growth Model was 0.005462, and the correlation between random slopes and intercepts was −.20. This correlation indicates that higher initial Mood A was associated with a lower rise in Mood A over the training and is shown in Figure 1.

The chi-square test showed that the Heterogeneous Growth Curve Model for Mood B fit the data significantly better than the Homogeneous Growth Curve Model (χ^2 [2] = 128.06, $p < .001$), indicating that changes in Mood B during training differed between individuals. The estimated initial mean of Mood B was 3.68 (t[188.66] = 93.24, $p < .001$) and the average change per week was 0.03 (t[187.03] = 9.64, $p < .001$), which is also in accordance with the results from the

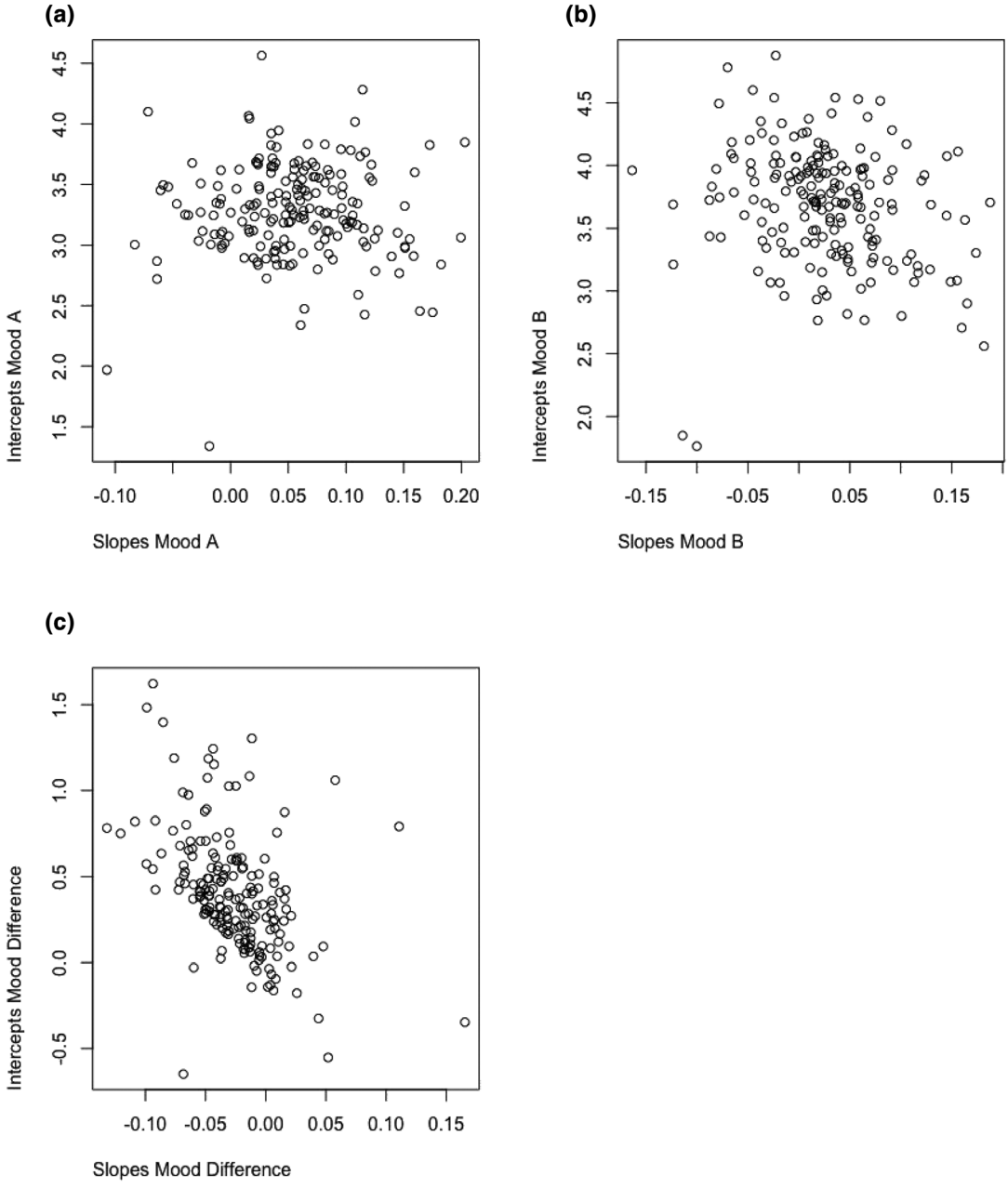

FIGURE 1 Correlations between intercepts and slopes in heterogeneous growth curve models. *Note*: Mood A= mood before daily intervention, Mood B = mood after daily intervention, Mood Difference = difference between Mood A and B.

Homogeneous Growth Curve Models. The estimated slope variance in the Heterogeneous Growth Model was .006155 and the correlation of random slopes and intercepts was −.31, indicating that higher initial Mood B was associated with a lower rise in Mood B scores over the training.

Finally, the chi-square test showed that the Heterogeneous Growth Curve Model fit the data significantly better than the Homogeneous Growth Curve Model (χ^2 [2] = 128.06, $p < .001$) also

in the case of Mood Difference scores, indicating that changes those scores during the training differed between individuals. The estimated initial mean of Mood Difference was 0.40 (t [189.03] = 13.07, $p < .001$) and the average change per week was −0.03 (t[187.99] = −5.105, $p < .001$), similar to the results from the Homogeneous Growth Curve Models. The estimated slope variance in the Heterogeneous Growth Model was .002678, and the correlation between random slopes and intercepts was −.51, indicating that higher initial Mood Differences were associated with a slower decrease in the Mood Difference over the training.

Improvements in mood and individual difference variables

To test whether dispositional mindfulness and narcissism moderated the change in the indices of mood, we included the individual difference variables as covariates in our Heterogeneous Growth Models. We also included the assessment group as a moderator to ascertain that participants who took part in the training during the first and the second 6 weeks were comparable. Specifically, we examined whether there were cross-level interactions between the level 2 variables and the level 1 variable (days/week of training), which would suggest that the effect of training on mood depends on the level 2 variables. The fixed effect estimates of the models are shown in Table 1.

The cross-level interactions between grandiose and vulnerable narcissism as well as dispositional mindfulness (level 2) and days (level 1) were not significant for Mood A, Mood B, and Mood Difference at a Bonferroni-corrected alpha level of .017. We found dispositional mindfulness to be a significant predictor of Mood A and Mood B when it was included in heterogeneous growth curve models but was not allowed to interact with the days (level 1) variable. This effect was independent of the significant effect of the training and suggests that dispositional mindfulness was associated with reporting higher mood before and after each session.

Differences in trajectories of change

To further explore the variance in individual slopes, we extracted individual trajectories in daily-measured Mood A, Mood B, and Mood Difference per participant throughout the weeks of the training. Figure 2 illustrates that although most participants showed steady mood increases, there was a percentage of participants that showed steady decreases in mood during the training.

Specifically, during the training Mood A increased for 83.68% of participants, Mood B increased for 70% of participants, and the difference between Mood A and Mood B decreased for 80% of participants. Those results suggest that while the majority (about 80%) of participants benefited from the training, there was a small percentage of those who did not.

We explored whether the two groups differ systematically with reference to dispositional mindfulness and narcissism. To compare individuals who showed an increase in mood or mood difference throughout the training (i.e., with a positive slope in Figure 2) to those who showed a decrease in mood or mood difference (i.e., with a negative slope in Figure 2) in relation to their levels of grandiose and vulnerable narcissism, and their dispositional mindfulness we conducted t-tests for independent samples. We performed separate analyses for participants whose mood cumulatively increased vs. decreased during the training as indicated by Mood A, Mood B, and Mood Difference indices. For all indices, the between-group comparisons

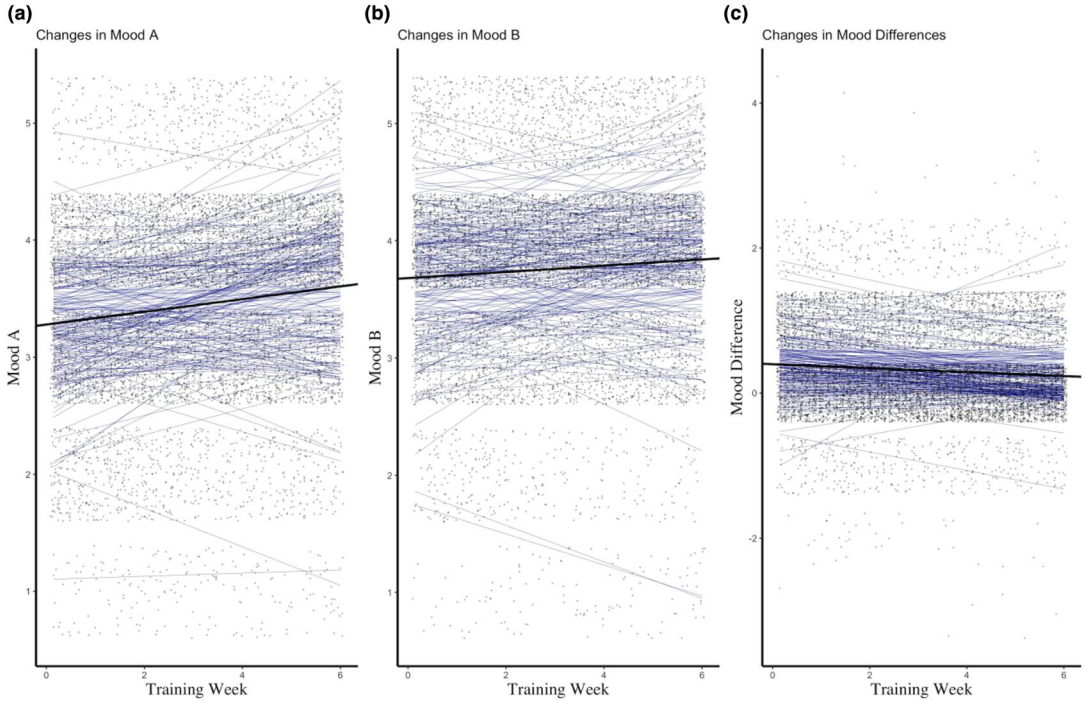

FIGURE 2 Changes in daily-measured mood throughout the training. *Note*: Mood A = mood before daily intervention, Mood B = mood after daily intervention, Mood Difference = difference between Mood A and B. Blue lines represent individual predicted mood levels throughout the training. Black lines represent trends according to heterogeneous growth curve models.

indicated no significant differences at a Bonferroni-corrected alpha error level of .017 (for detailed results, see Table S3).

DISCUSSION

We used Multilevel Growth Curve Modelling to examine the trajectories of daily mood improvements during a 6-week mindfulness-based intervention (for a detailed description and feasibility analyses, see Golec de Zavala, Ziegler, Keenan, Ciesielski, Mazurkiewicz, Wahl, Nalberczak-Skora, & Sedikides, 2023). We tested whether the change in mood is indeed linear and incremental as can be predicted from the Mindfulness-to-Meaning model (Garland & Fredrickson, 2019), and whether individual differences in trajectories of change exist.

We examined mood assessed before and after each of the daily audio-guided mindfulness sessions. The first index reflects cumulative change due to the training, while the second represents incremental change due to each session. We also examined the trajectories of the daily differences between the initial and post-session mood. The decrease in this index represents stabilization of the improvement during the training. As the training unfolds, this index should become smaller. We detected trajectories suggesting linear cumulative (83.63% of participants) and incremental (70% of participants) increase in positive mood that stabilized as the training progressed (80% of participants).

The linear, everyday increase in mood measured before each session suggests that the training worked cumulatively, steadily increasing participants' mood. In other words, participants started each day of practice in a better mood than the previous day. The training worked incrementally, steadily increasing mood after the session in comparison to mood before the same session. The cumulative change was larger than the incremental change. The linear increase was stronger for mood assessed before sessions in comparison to mood measured after sessions, and it was displayed by a larger percentage of participants. In addition, the difference between mood before and after sessions decreased during the training. This suggests that the training worked steadily to stabilize mood improvements over time. Thus, as predicted by the Mindfulness-to-Meaning model (Garland & Fredrickson, 2019), the effects of mindfulness practice on positive mood are linear, cumulative, and incremental for the majority of participants.

However, those effects are not the same for all participants. Participants reporting lower mood at the first day of the training benefited from the training more than participants with higher initial mood. Among participants starting in the lower mood, the linear increases in mood measured before and after each session were steeper than among participants who started the training in a more positive mood. This suggests that participants starting the training in a worse mood improved more than participants who started in a better mood. This also suggests that the novel mindfulness-based training serves its purpose and brings the largest mood improvements to participants who need it the most.

While the mindfulness-based training was beneficial for most participants, it was not beneficial to all of them. Some participants showed a steady, cumulative, and incremental decrease in mood during the training, and their mood did not stabilize in the course of the training. The two groups of participants – Improvers and Decreasers – did not differ significantly with reference to any of the examined individual difference variables. Dispositional mindfulness or individual narcissism measured at baseline were not associated with trajectories of the mood change. Thus, individual differences in those variables do not allow us to predict different trajectories of mood changes during the intervention.

The present results extend the mindfulness literature in several ways. While multiple studies examined the pre- to post-intervention changes in positive mood and well-being averaged across participants (e.g., Goldberg et al., 2022; Kuyken et al., 2016), only few studies investigated the dynamics of this change in more detail (e.g., Krick et al., 2021; Snippe et al., 2017; Yuan, 2021). Studies using denser temporal sampling of psychological changes during mindfulness-based interventions indicate a linear increase in resilience (Krick et al., 2021; Yuan, 2021) and a linear decrease in stress and negative affect (Snippe et al., 2017). The present results extend the previous findings indicating that positive mood also increases during mindfulness-based intervention in a linear, incremental, and cumulative fashion.

Secondly, our findings suggest that despite the general increase, there is inter-individual variance in how participants' mood changes due to the training. Those who start in a better mood and benefit quickly may not need a long training course to show a significant improvement in well-being. A longer training may work better for those with lower initial mood who need mood improvement more. This is in line with findings pointing to a similar trajectory among high starters in a study that looked at mindfulness-based intervention effect on heart rate variability associated with physiological indicators of emotional resilience (i.e., HRV; Krick et al., 2021). Importantly, while dispositional mindfulness predicted higher mood measured before and after each session, it did not moderate the effects of the training on the cumulative and incremental mood increase. Those findings align with previous results pointing to dispositional mindfulness predicting well-being (Prieto-Fidalgo et al., 2022; Tomlinson et al., 2018),

but also suggest that being mindful and practicing mindfulness are not the same even if both are associated with positive changes in mood over time. As individual narcissism did not seem to play any role in how participants reacted to the mindfulness training, the present results suggest that mindfulness-based interventions may not be effective in improving emotional deficits associated with narcissism, despite the results indicating they can positively affect attachment styles associated with narcissism (cf. Desbordes, 2019).

Finally, the present results address the recent discussions regarding the possible long-term, adverse effects of mindfulness practice and mindfulness-based interventions (Anālayo, 2019; Britton, 2019; Britton et al., 2021; Hanley et al., 2016). Some analyses suggested that while most participants tend to experience some adverse effects during mindfulness practice, those effects do not cause harm or affect the overall, long-term positive effects of mindfulness practice (Aizik-Reebs et al., 2021). However, other authors report that long-lasting negative effects such as dissociation are found in 4–16% of participants, a percentage similar to adverse effects of other mood-improving psychological treatments (Britton et al., 2021). In line with the later findings, we found that about 16% of our participants experienced a linear, cumulative decline in mood during the mindfulness-based training. In the light of such findings, it seems crucial that future studies explore factors that differentiate those participants from those who find the training beneficial.

LIMITATIONS

The present study is not without shortcomings that need to be considered while interpreting its findings. The present study used a convenience sample that was imbalanced in terms of gender and predominantly female. However, it is unlikely that this imbalance affected our results. A recent meta-analytical summary of findings in mindfulness intervention literature shows that the effects of those interventions are similar in both gender groups, but typically smaller among women than among men (Goldberg et al., 2022). This suggests that our study provides a conservative test of our predictions. Nevertheless, future studies would do well replicating those tests in a gender-balanced sample.

Additionally, we relied on self-report, one-item assessment of general mood ranging from negative to positive. This is a less rigorous indicator of well-being than multi-item measures and objective measures of well-being such as physiological and behavioral assessments. It is unlikely that these shortcomings account for the results, nevertheless future studies would do well using more rigorous and objective assessments of positive mood.

Finally, as the study was designed to address the Polish non-clinical population during the COVID-19 pandemic, the question of generalizability of the present findings also remains to be tested by future studies. However, it is worth noting that the present findings are in line with many previous findings in the mindfulness literature conducted on other populations and outside of the period of the pandemic. This increases our trust in the generalizability of our findings.

PRACTICAL APPLICATIONS

The present results provide a more comprehensive understanding of individual differences in incremental mood improvement during the mindfulness-based intervention than the examination of overall improvements averaged across individuals. Learning more about individual variability in benefiting may help to streamline and adapt the interventions to the needs of specific

groups to optimize the intervention effectiveness. For example, participants who start in a better mood may benefit from shorter interventions. On the other hand, longer interventions may be recommended for participants with lower initial mood. Those participants show steeper initial improvements that need to be further boosted in the later part of the training to stabilize the effects. This person-oriented approach can help clinical practitioners to calibrate how much of the mindfulness-based intervention is required for different individuals to noticeably improve. It may also help to identify groups of participants that benefit from mindfulness-based interventions differently and those for whom mindfulness-based intervention may not be beneficial at all. Our understanding of different trajectories of improvement may be incorporated in mindfulness apps that can be programmed to adjust the course of the intervention according to the individual progress of participants.

Our findings underscore the importance of caution while prescribing mindfulness-based intervention to support stress or anxiety treatments. While those interventions have positive effects on most participants, a small group of participants shows consistent mood decline during the mindfulness-based intervention. While the percentage of people suffering such effects is not higher than in the case of other psychological interventions (Britton et al., 2021), future studies would do well to investigate more thoroughly the factors that may restrict the effectiveness of mindfulness interventions. Mindfulness apps can be programmed to detect incrementally decreasing moods and alert clinical practitioners when the intervention is not working to substitute it with a more suitable alternative.

ACKNOWLEDGMENTS

The authors would like to thank Julia Wahl for project administration and Kinga Bierwiaczonek for the initial supervision of data curation.

CONFLICT OF INTEREST STATEMENT

The Authors declare no conflict of interests.

DATA AVAILABILITY STATEMENT

Data and analyses codes and study materials are available in open access https://osf.io/8p7au/?view_only=9223f6a5b32a4ac68bfed6907747b653.

ETHICS STATEMENT

The study was approved by the university's ethics committee (decision 02/P/04/2020). Participants signed informed consent. Data and codes are available at https://osf.io/8p7au/?view_only=9223f6a5b32a4ac68bfed6907747b653.

DISCLOSURE STATEMENT

The authors report there are no competing interests to declare.

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How to cite this article: Golec de Zavala, A., Förster, C., Ziegler, M., Nalberczak-Skóra, M., Ciesielski, P., & Mazurkiewicz, M. (2024). The shape of the change: Cumulative and incremental changes in daily mood during mobile-app-supported mindfulness training. *Applied Psychology: Health and Well-Being*, 1–19. https://doi.org/10.1111/aphw.12518