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Web-based training for post-secondary student well-being during the pandemic: a randomized trial

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ABSTRACT

Background: The COVID-19 pandemic has been a highly stressful period where post-secondary education moved to online formats. Coping skills like decentering and reappraisal appear to promote stress resilience, but limited research exists on cultivating these skills in online learning contexts.

Methods: In a three-arm randomized trial design, we evaluated three-week, web-based interventions to gauge how to best cultivate mindfulness and stress-reappraisal skills and whether the proposed interventions led to improved mental health. Undergraduate participants (N = 183) were randomly assigned to stress mindset, mindfulness meditation, or mindfulness with choice conditions.

Results: At the study level (baseline vs. post-intervention), decentering improved across all conditions. Mindfulness with choice significantly decreased negative affect and rumination compared to stress mindset, while stress mindset significantly enhanced stress mindset skills compared to both mindfulness groups. At the daily level (three sessions per week), stress mindset significantly increased positive affect compared to mindfulness meditation.

Conclusions: Results suggest that student mental health can be remotely supported through brief web-based interventions. Mindfulness practices seem to be effective in improving students' negative mood and coping strategies, while stress mindset training can help students to adopt a stress-is-enhancing mindset. Additional work on refining and better matching students to appropriate interventions is needed.

The COVID-19 pandemic has been a highly stressful period for university students, in which in-person education haphazardly moved to online formats. Prior to the pandemic, university students had already demonstrated a heightened prevalence of mental health problems (Auerbach et al., 2018). Unfortunately, students' vulnerability has likely been exacerbated by pandemic-related restrictions, with concerns over income, work, safety, social interaction, and academic performance contributing to mental health burden (Son et al., 2020; Zhou et al., 2020). Accordingly, students have reported increased levels of stress, anxiety, loneliness, and depressive symptoms during the pandemic (Copeland et al., 2021; Fruehwirth et al., 2021; Huckins et al., 2020). Elevated stress is strongly linked to acute dysfunction in the form of depression and anxiety disorders (Gallagher et al., 2020; Hammen et al., 2009; Kendler et al., 2003); pandemic-related role loss, anxiety and isolation have undoubtedly contributed to global stress levels and may require innovation to support the most vulnerable members of our society (Horesh & Brown, 2020).

Fortunately, adaptations of existing mental health interventions appear to have strong and sustainable benefits for supporting student mental health (Winzer et al., 2018). For example, Mindfulness-based interventions (MBIs), Cognitive Behavioral Therapy (CBT), and Acceptance and Commitment Therapy (ACT) have all demonstrated efficacy in post-secondary contexts (Dawson et al., 2020; Grégoire et al., 2018; Huang et al., 2018; Ma et al., 2019). Existing psychological treatments might therefore be adapted to improve coping skills and reduce the distress of those suffering from social isolation and other pandemic-related challenges (Polizzi et al., 2020).

Online interventions represent one sensible approach for supporting student mental health when in-person and/or group therapies are less available. Accessible through mobile apps or via a web browser, online interventions provide access to mental health training that is confidential, scalable to large groups, and flexible in terms of location and time (Bolinski et al., 2020; Saddichha et al., 2014; Sommers-Spijkerman et al., 2021), and have been used effectively to treat depression (Crisp et al., 2014; Segal et al., 2020) and anxiety (Benton et al., 2016; Tribe et al., 2021).

Pre-pandemic investigations suggest that online interventions may be effective in reducing students' feelings of stress and depression (Nguyen-Feng et al., 2017), although results are mixed (c.f., Farrer et al., 2019). Encouraging, a pilot study on a single-session online mental health intervention suggested that it was generally acceptable, engaging, and helpful in managing COVID-related challenges (Wasil et al., 2021). Despite these promising findings, there is limited research on how to *best* support student mental health during the pandemic, despite the documented need for prevention and early intervention (Galea et al., 2020). Furthermore, even though previous studies have differentiated online interventions with respect to their ability to cultivate specific coping skills (Bolinski et al., 2021; Harrer et al., 2019), little research has compared the relative efficacy of distinct coping skills to enhance well-being during the pandemic. At least two major categories of coping skills have been implicated in efficacious mental health interventions: decentering and positive reappraisal (Hanley et al., 2021; O'Toole et al., 2019).

Decentering is described as "a process through which one is able to step outside of one's immediate experience, thereby changing the very nature of that experience" (Safran & Segal, 1990, p. 117). Decentering is perhaps best known as a mechanistic target in mindfulness-based interventions such as Mindfulness-Based Cognitive Therapy (Segal et al., 2002), but it is also featured in various other "third wave" therapies, such as Acceptance and Commitment Therapy (Yu & McCracken, 2016) and Cognitive Behavioral Therapy (Fresco et al., 2007), and is theorized to be a common therapeutic mechanism across a variety of affective and anxiety disorders (Hayes-Skelton et al., 2015; Segal et al., 2019). Decentering interventions focus on viewing one's thoughts, emotions, and physical sensations as transient internal experiences from a distant perspective, without reacting automatically or getting involved with them (Hanley et al., 2020). Some decentering practices include introspective/perspective-taking, mindfulness, journaling, and reflective exercises (Abel et al., 2012).

Positive reappraisals, on the other hand, seek to consciously overwrite negative perceptual or behavioral habits, reappraise negative situations, and identify positive aspects of experience (Crum et al., 2017; Jamieson et al., 2018). It is a value-based strategy used to search for positive meaning among negativity to cope with stressful life events (Nowlan et al., 2015). Successful reappraisal interventions are thought to reduce stress by reducing the salience of negative appraisals in favor of engagement with positive aspects of experience (Folkman & Moskowitz, 2000). Positive reappraisal practices encourage individuals to identify personally-relevant positive meanings from stressful experiences following an initial negative impression (Nowlan et al., 2015).

Mindfulness-to-Meaning Theory (MMT) posits that there are benefits to combine decentering and reappraisal strategies. Specifically, MMT suggests that *decentering promotes reappraisal*, leading to a greater sense of meaning in life and contributing powerfully to well-being (Garland et al., 2017). Specifically, MMT suggests that individuals decenter from stress appraisals into a metacognitive state of awareness, resulting in broadened attention that can identify concurrent positive aspects

of experience (Garland et al., 2015). It should be noted that such directionality is not confirmed, with some evidence that reappraisal can precede decentering (Kobayashi et al., 2020), and MMT allows for dynamic cycles of decentering and reappraisal, in keeping with the extended process model of emotion regulation (Gross, 2015). Regardless of the order, MMT suggests that training both decentering and reappraisal capacities is beneficial in a broader framework of "spiraling upward" toward human flourishing (Garland et al., 2011). However, whether decentering or positive reappraisal is a more important target of initial training remains unclear, despite the potential for either capacity to benefit students' mental well-being during the pandemic.

To promote decentering, mindfulness interventions are commonly used (Shoham et al., 2017). Teachable mindfulness techniques may reduce anxiety (Khoury et al., 2013; Hoffmann et al., 2021), foster awareness of thoughts, emotions, and sensations (Blanke et al., 2020; Farb et al., 2007), aid in the development of adaptive regulatory strategies (Alkoby et al., 2019; Farb et al., 2013), and cultivate goals and action commitment (Coffey & Hartman, 2008; Wang et al., 2020). These effects seem to generalize to pandemic-related stress, as an implementation of mindfulness relaxation techniques (e.g., progressive muscle relaxation) has been shown to be effective for reducing anxiety symptoms and improving sleep quality in patients diagnosed with COVID-19 (Liu et al., 2020).

To reach students operating from many different locations and time zones, mindfulness interventions have been adapted from intensive group formats to online, minimally intrusive formats. The use of online mindfulness interventions has grown rapidly over the past decade, with a recent meta-analysis identifying 97 online, mindfulness-based interventions (MBIs; Sommers-Spijkerman et al., 2021); the analysis suggested that online MBIs show moderate effects on depression, stress, and dispositional mindfulness with small effects on anxiety and well-being. Moreover, approximately one-third of the studies reviewed focused on post-secondary student samples, emphasizing online MBI efficacy in this population. For instance, Mak et al. (2015) implemented an 8-week internet-based mindfulness intervention on university students and found significant improvements in students' mindfulness and mental well-being. Similarly, students who reported more frequent use of the mindfulness meditation app, Headspace, demonstrated enhanced psychological symptoms and college adjustment (Flett et al., 2020). The successful implementation of online and app-based mindfulness interventions strengthens the possibility of utilizing online mindfulness interventions to support students during the pandemic.

For positive reappraisal interventions, stress mindset training has shown positive outcomes in developing new perspectives, meaningfulness, and heightened awareness (Crum et al., 2020). Stress mindset can be conceptualized as internalizing the belief that stress can have enhancing consequences for performance, productivity, health and well-being, and learning and growth (i.e., a "stress-is-enhancing mindset"), rather than believing that stress has debilitating consequences (i.e., a "stress-is-debilitating mindset"; Crum et al., 2013). Previous research has found that people with a stress-is-enhancing mindset tend to show better responses to perceived stress and anxiety (Huebschmann & Sheets, 2020), less likely to experience personal burnout (Klussman et al., 2020), and reported improved psychological symptoms and performance (Crum et al., 2013) than others with a stress-is-debilitating mindset. Like mindfulness interventions, stress mindset training features several publicly accessible, validated exercises that may be adapted for online use (Crum et al., 2013; Jamieson et al., 2018). The efficacy of online stress mindset interventions to support individuals' psychological well-being is almost completely unknown, although there does not seem to be an a priori reason barring its translation into an online format. Given the efficacy of stress mindset training described above, such adaptation seems to have strong potential for supporting student resilience in a university setting.

Despite their potential (Brockman et al., 2017; Keng et al., 2013), to our knowledge, decentering and positive reappraisal interventions have not been directly compared for their ability to promote student well-being amidst the challenges of working remotely during the pandemic. A further question for the ecological validity of online training is how to foster interactivity and engagement. One possibility is including a choice among a set of learning activities, which has been shown to increase

motivation and knowledge transfer (Merrill, 2002). Motivated learners tend to be more engaged and report greater satisfaction (Paas et al., 2005). The inclusion of choice in learning has been prominently featured in clinical MATCH trials, resulting in improved treatment outcomes and more efficient use of health care services (DeRubeis et al., 2014; Huibers et al., 2015; Khan et al., 2019). Thus, both the content of the training (decentering vs. reappraisal) and the availability of choice in selecting lessons within a given content area might be fruitful areas of inquiry for supporting student mental health.

In the present study, we explored the potential of web-based mental training interventions developed to support undergraduate students' psychological well-being during COVID-19. We included three intervention groups: stress mindset, mindfulness meditation, and mindfulness with choice. Our primary aim was to validate online training modules for training decentering and reappraisal, the core components of Mindfulness-to-Meaning Theory. We, therefore, developed web-based adaptations of mindfulness and stress mindset training to explore their potential to improve students' mood, mental health, and coping skills. Due to the urgent need for mental health support amidst the pandemic, we did not use a passive control group to avoid depriving any participant of the opportunity to improve mental health and resilience. While this design choice limited the opportunity to control for natural effects over the intervention period, the selection of interventions already known to be efficaciously reduced the importance of showing basic efficacy relative to a passive control condition. A secondary aim was to evaluate whether providing additional choice around training modules would improve participant retention and outcomes. In the literature, choice has been shown to improve participant engagement and outcomes (Reeve et al., 2003). To this end, a second version of mindfulness training (i.e., the mindfulness with choice group) was developed which allowed participants to choose between exercises. No additional choice-based stress mindset group was developed because we adopted the training materials directly from Crum et al. (2017).

All hypotheses were pre-registered before data collection (https://osf.io/3n6xj). The main hypothesis was that while all interventions would be beneficial, they might show different levels of efficacy and impact different regulation skills. Our null hypothesis (H0) was that all participants would show increased stress coping ability over time, with no conditional difference. At the study level, we hypothesized that our two mindfulness groups would show advantages in improving participants' stress coping ability (H1), mental health (H2), positive coping (H3), and negative coping (H4) compared to the stress mindset group. At the daily level, we predicted that our two mindfulness groups would show decreased stress levels (H5), improved positive mindset (H6) and decentering levels (H7) compared to the stress mindset group. Additionally, we hypothesized the potential choice effect such that the mindfulness with choice group would show the greatest stress reduction (H8) and improvements in positive mindset (H9) compared to both the stress mindset group and the mindfulness meditation group at the daily level.

Deviation from preregistration

To create a simpler account and reduce the potential for Type-I errors, we pre-registered the intention to create composite scores for mental health and coping abilities using established self-report measures. However, inspection of factor loadings for the purpose of data reduction revealed that some seemingly overlapping measures failed to load onto a single factor, which suggests that reducing these measures to a single composite score would not be appropriate, but rather those measures should be retained in their original forms and investigated separately. Corrections for multiple comparisons were updated to reflect a larger expected number of variables. The Methods section describes final set of measures used in the study; however, please consult "Supplementary Materials – Measures" for a description of the pre-registered factor loadings and the rationale for retaining individual measures. The decision to exclude measures from composite scores was made *prior* to hypothesis testing on these composite scores.

In addition, we initially described the Stress Mindset condition as the "University Success (US)" condition in the pre-registration but changed the name to Stress Mindset to better indicate the focus of the training.

Method

Participants

Participants were undergraduate students from the PSY100 Fall 2020 class at the University of Toronto Mississauga and they were recruited via the online participant pool. Through our study, students were able to obtain up to 3% course credit towards their class grade. The research protocol was approved by the University of Toronto Social Sciences, Humanities, and Education Research Ethics Board (REB).

A priori power analysis was conducted with G*Power Software (version 3.1) before participant enrollment. With the consideration of family-wise power for multiple comparisons (Peña et al., 2011), and including 10 comparisons (i.e., 10 hypotheses), we planned to keep familywise $α ≤$ 0.05, using a conservative Holm-Bonferroni correction at the level of individual tests that set test $α ≤ 0.005$ and family-wise power at 0.989. These parameters yielded a required sample size of $N =$ 123 to achieve correction for multiple comparisons; to account for expected participant attrition over time (i.e., 25%), we aimed to recruit at least $N = 164$ (123/0.75) or 55 participants in each group.

A total of 251 students declared an initial interest in the study. See Figure 1 for the process by which the final participant sample was formed. Upon recruitment, each participant was asked to complete a pre-screener assessment of well-being through a web-based survey platform called Qualtrics. Participants were excluded from the study if they had an ongoing cognitive or mood disorder, including substance use disorders, or previous diagnosis of such a disorder within the past year.
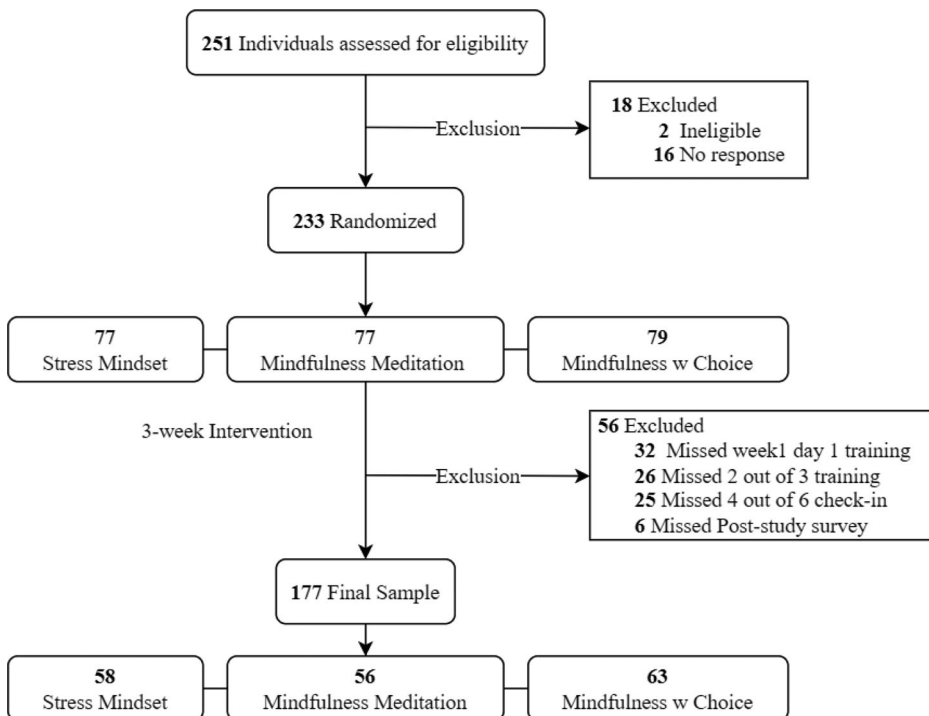

Figure 1. Diagram summarizing participant flow.

Students who claimed that they did not experience moderate or high levels of daily stress and who answered "no" to complete the required study sessions were automatically excluded from participation during the pre-screener survey. Based on these criteria, 18 students were excluded from the study.

The remaining sample of 233 participants completed the baseline questionnaire and informed consent. They were randomly assigned to the three conditions: stress mindset ($N = 77$), mindfulness meditation ($N = 77$), and mindfulness with choice ($N = 79$). Randomization was performed autonomously with the built-in Qualtrics survey platform by selecting a random group value (1, 2, or 3) without replacement, which is equivalent to block randomization where each participant was randomly assigned to one of the three equally sized, predetermined blocks. Each student was provided with the schedule and future participation instructions at the end of the baseline assessment. The final participant sample excluded 50 students due to inability to attend week 1 day 1 training ($N = 32$), dismissal for excessive absences for training sessions (missed two out of three; $N = 26$) or check-in sessions (missed four out of six; $N = 25$). Some participants fit more than one exclusion criteria. The final sample size included 183 participants who finished the required study sessions and 177 of them completed the final post-study assessment. Participants' age was collected ($M = 18.5$ years, SD = 1.47), and 81.4% of the sample identified as female.

Interventions

The three interventions offered equal dosage of instruction: participants attended up to 9 sessions over 3 weeks, with a longer (~20 min) first session each week delivering condition-specific training, while the second and third sessions provided brief (~3 min) check-ins. Participants were asked to rate their levels of stress, mood, motivation, and decentering at the beginning and end of each training session while check-ins only included these ratings.

Stress mindset condition

The stress mindset condition was adopted from Crum et al. (2017), which focused on reappraising stress as potentially enhancing performance and developing a stress-is-enhancing mindset. In week 1, participants watched videos on the power of mindset and how to reframe stress as beneficial for their well-being and overall performance. They were taught to acknowledge stress, welcome stress, and utilize stress for moving to a stress-is-enhancing mindset in week 2 and applied what they have learned about reappraising stress with daily life examples in week 3.

Mindfulness meditation condition and mindfulness with choice condition

We compared the stress mindset condition to two forms of mindfulness trainings, which taught participants to accept their internal experience and be present, choose a valued direction and take action. Training videos were based on the MBIs (e.g., body scan, mindful breathing) and were recorded by the current researchers and uploaded onto Qualtrics for online asynchronized learning. Participants were introduced to the world of mind and language, practiced exercises to make room for different feelings, sensations, urges, and emotions, and learned techniques to identify their values and got prepared for their future academic success. The mindfulness meditation condition involved a predetermined order of practice activities while the mindfulness with choice condition allowed participants to choose exercises under the same weekly theme. For instance, to practice present moment awareness in week 1, they could choose among body scan, five senses, and mindful breathing exercise.

Materials

Mental health and coping data were assessed and analyzed at two levels: the study level (baseline vs. post study) and the daily level (3 check-ins per week).

The study level (baseline and post-intervention measures)

Stress Coping. This was further divided into two individual variables: stress and stress mindset. Stress was assessed with the Perceived Stress Scale (PSS; Cohen et al., 1983), which is a 10-item scale used to measure how different situations affect people's feelings and perceived stress. It assessed participants' current level of experienced stress on a scale of 0 to 4, with 0 being "never" and 4 being "very often." The Cronbach's alpha was 0.86 in our sample, which suggests good internal consistency. Stress mindset was measured with the Stress Mindset Measure (SMM; Crum et al., 2013), which is an 8-item measure to address whether one person adopts a "stress-is-enhancing mindset" or a "stress-is-debilitating mindset." Different stress mindsets are correlated with differential motivation and approaches when facing stress and influence future long-term health and performance outcomes. Participants were asked to rate the extent to which they agreed or disagreed with each item on a scale ranging from 0 (strongly disagree) to 4 (strongly agree). Higher scores represent the mindset that stress is enhancing. The Cronbach's alpha was 0.80 in our sample, which means good internal consistency.

Mental Health. This was further divided into two individual factors: positive affect and negative affect. Positive and negative affect were assessed with the Positive and Negative Affect Scale (PANAS; Watson et al., 1988). It contains 20 questions (10 questions for each domain) assessing the extent to which an individual feels pleasant and energetic, or upset and afraid. Participants rated the extent to which they felt different feelings and emotions during the past week on a scale ranging from 1 = "very slightly or not at all" to 5 = "extremely." Higher scores of each domain indicated higher levels of positive affect or negative affect. The Cronbach's alphas were 0.88 for positive affect and 0.82 for negative affect in our sample, suggesting good internal consistency.

Additionally, the Patient Health Questionnaire for Anxiety and Depression (PHQ-4; Kroenke et al., 2009) was used to measure the presence of depression, anxiety, and somatic symptoms among students at the study level. However, as the PHQ-4 score did not load well onto a composite factor with negative affect, the PHQ-4 was only retained as to better describe the sample baseline characteristics and was not included as an indicator of negative affect (please see the Supplementary Materials for further details).

Positive Coping. This was divided into two distinct factors: decentering and positive reappraisal. Decentering was assessed with the Experiences Questionnaire (EQ; Fresco et al., 2007) Decentering subscale. The EQ-Decentering subscale contains 14 items designed to measure disidentification with the content of negative thinking. Responses were rated on a 5-point Likert scale (1 = "never," 5 = "all the time"). Higher scores indicated better decentering skills. In our sample, Cronbach's alpha was 0.73, suggesting acceptable internal consistency. Positive reappraisal was measured with the Cognitive Emotion Regulation Questionnaire (CERQ; Garnefski & Kraaij, 2007) Positive Reappraisal subscale. It includes two items assessing individual differences in emotion regulation in response to stressful situations. The Cronbach's alpha was 0.80 in our sample, suggesting good internal consistency.

Negative Coping. This was measured by the Ruminative Response Scale (RRS; Treynor et al., 2003). The RRS is a 22-item self-report measure of rumination and individuals' coping strategies when responding to depressed mood with three factors (Depression, Reflection, and Brooding). Participants rated each item on a scale from 1 = "almost never" to 4 = "almost always." Higher scores indicated higher degrees of ruminative symptoms. The Cronbach's alpha was 0.91 in our sample, suggesting excellent internal consistency.

The daily level (3 sessions per week)

Stress. This was assessed using the stress slider (Fiodorova & Farb, 2022) rating from 0 (no stress) to 10 (extreme stress). Participants were asked to slide to the number that accurately reflected the level of stress they experienced at that moment.

Positive mindset. This was further divided into two distinct factors: motivation and positive affect. Motivation was assessed using the motivation slider rating from 0 (no motivation) to 10 (highly motivated). Participants were asked to indicate how motivated they felt they could focus on their current work. Positive affect was assessed using the Mood Board Circumplex, which is a visual representation of positive and negative emotions on a spectrum, ranging from intense emotions to mild emotions (Walsh et al., 2019). Participants were asked to select at least 1 out of 16 items that represented their feelings at that moment.

Decentering. This was assessed using two items from the Experience Questionnaire (EQ): "I have the sense that I am fully aware of what is going on around me and inside me" and "I view things from a wider perspective". Respondents were asked to indicate whether these statements matched their current state, ranging from 1 (strongly disagree) to 5 (strongly agree).

Procedure

Participants self-enrolled through a research participation website ("PsychED") administered by the Department of Psychology at the University of Toronto Mississauga. Participants enrolled in Fall 2020 by completing a pre-consent screener which provided study information and automated feedback about inclusion and exclusion criteria; this data was not retained but eligible participants were able to complete self-enrollment by leaving their email address, which then scheduled a subsequent email to deliver a web link to informed consent materials and the baseline assessment survey.

All study materials, including consent forms, were presented using the Qualtrics online survey platform (Qualtrics, Provo, UT). Following completion of informed consent and the baseline assessment, participants were randomly assigned without replacement into one of the three intervention conditions using the random assignment function built into the Qualtrics platform. At the conclusion of the baseline, participants were provided with a timetable that indicated the customized date that they would receive training sessions and check-in surveys. They received a 20-min training session each week followed by two 3-min check-in sessions for three weeks. Each link expired after 24 h of receiving and they had an additional 24 h to complete each session once they started. After the 3-week interventions, they received a post-study survey assessing the same outcome variables that were included in the baseline survey.

Data analysis

Self-reported measures for the study level analysis were assessed at baseline and post-intervention session. Participants completed nine additional brief assessments on stress, decentering, positive affect, and motivation for three weeks. A three-level multilevel regression model was used to analyze our results, as implemented in the "nlme" package in the R statistical programming environment (Revelle, 2018). To test for intervention effects across primary measures (H1–H9) a multilevel model of the interaction of conditions (stress mindset vs. mindfulness mediation vs. mindfulness with choice) with time (baseline vs. post-intervention for the study level; nine sessions for the daily level), controlling for participant identity with distinct ID number was conducted; the R syntax would resemble:

$$DV \sim Condition \times Time + (1|ParticipantID)$$

which executes the complete multilevel model:

$$DV \sim N(\alpha_{j[i]} + \beta_1(Time),\ \sigma^2)$$

$$\alpha_j \sim N(\gamma_0^\alpha + \gamma_1^\alpha(Condition) + \gamma_2^\alpha(Condition \times Time),\ \sigma^2),\ \text{for ID}_{j=1,\dots,J}$$

where DV = dependent variable score for an individual observation at level 1, j indexes the participant in the sample, i indexes the individual case/score within a participant, N is the number of participants, α is the second level regression coefficient, β is the overall regression coefficient for time (fixed effect of time), γ refer to the intercept γ_0 and slopes γ_1 and γ_2 for the relationship between the predictors and the dependent variable nested within participant.

The primary outcome of each test was the Condition x Time interaction. To maintain a familywise error rate $\alpha < 0.05$, we employed the Benjamini-Hochberg correction for controlling the Holm-Bonferroni over multiple comparisons (Benjamini & Hochberg, 1995; Table S1).

Results

Baseline characteristics

The study employed a mixed-model, multilevel randomized trial in R software. Most participants (76%) completed the study protocol, with no differences between conditions. Based on the scoring bins for the Perceived Stress Scale, a majority of students (56%) reported high levels of stress while relatively few (16%) reported low levels at baseline. Based on the PHQ-4, 58% of students reported mild symptoms of anxiety, 14% reported moderate symptoms of anxiety, 32% reported mild depressive symptoms, and 8% reported moderate depressive symptoms at baseline (Kroenke et al., 2009).

Pre-registered results

All statistical analyses on pre-registered variables were presented in Table 1.

The study tested the primary hypotheses that all intervention conditions would improve stress coping at the study level (Baseline to Post-Intervention), as indexed by the change in perceived stress and stress mindset (H0), with bigger advantages in mindfulness conditions (H1). No effect of time on stress was found but a positive effect of time was observed for the stress mindset variable, such that stress mindset increased over time. The stress mindset condition significantly increased stress mindset compared to both mindfulness meditation and mindfulness with choice condition (Table 1, Figure 2(A)).

Furthermore, we hypothesized that greater improvements would be found in mindfulness conditions compared to the stress mindset condition on mental health (positive and negative affect; H2), positive coping (decentering and positive reappraisal; H3), and negative coping (rumination; H4) at the study level. No evidence of a difference was found across conditions for positive affect, while the mindfulness with choice condition demonstrated a significantly greater decrease in negative affect compared to the stress mindset condition (Table 1, Figure 2(B)). Decentering significantly increased over time for all participants, but there was no evidence of condition-related differences for either decentering or positive reappraisal (Table 1, Figure 2(C)). As for rumination, the mindfulness with choice condition demonstrated a significantly greater decrease in rumination compared to the stress mindset condition over time (Table 1, Figure 2(D)).

Additionally, at the daily level, we hypothesized that mindfulness conditions would have bigger advantages in improving stress reduction (H5), positive mindset (motivation and positive affect ratings; H6), and decentering (H7) than the stress mindset condition. No significant differences between conditions were observed in stress and motivation at the daily level (Table 1); decentering went up over time across all conditions (Table 1, Figure 2(E)). A significant interaction between time and condition was observed on positive affect when comparing the stress mindset condition to the mindfulness meditation condition, such that positive affect increased significantly more in the stress mindset condition compared to the mindfulness meditation condition (Table 1, Figure 2(F)).

Table 1. Pre-registered variable analysis summary at the study level (baseline vs. post-intervention) and the daily level (3 sessions per week).

Description	Beta	95% CI	p value	Beta	95% CI	p value
Study Level						
H0 & H1: Stress Coping		**(A) Stress**			**(B) Stress Mindset**	
Time	−0.35	[−1.79, 1.08]	.63	3.80	[2.75, 4.85]	<.001*
Time * Mindful Meditation	0.85	[−1.22, 2.91]	.42	−4.39	[−5.90, −2.88]	<.001*
Time * Mindful w Choice	−0.40	[−2.39, 1.58]	.69	−2.65	[−4.11, −1.20]	<.001*
H2: Mental Health		**(A) Positive Affect**			**(B) Negative Affect**	
Time	−0.45	[−2.08, 1.18]	.59	0.10	[−1.50, 1.70]	.90
Time * Mindful Meditation	−1.11	[−3.46, 1.24]	.19	−0.93	[−3.23, 1.38]	.43
Time * Mindful w Choice	0.88	[−1.38, 3.14]	.45	−2.28	[−4.50, −0.06]	.04*
H3: Positive Coping		**(A) Decentering**			**(B) Positive Reappraisal**	
Time	2.43	[1.35, 3.51]	<.001*	0.10	[−0.30, 0.50]	.62
Time * Mindful Meditation	−1.29	[−2.84, 0.27]	.11	0.26	[−0.31, 0.83]	.38
Time * Mindful w Choice	0.81	[−0.69, 2.30]	.29	0.00	[−0.55, 0.55]	.99
H4: Negative Coping		**Rumination**				
Time	2.21	[−0.05, 4.47]	.06			
Time * Mindful Meditation	−2.19	[−5.45, 1.07]	.19			
Time * Mindful w Choice	−3.74	[−6.87, −0.60]	.02*			

The reference condition is Stress Mindset
* indicates significant values at an uncorrected p < .05 threshold

Description	Beta	95% CI	p value	Beta	95% CI	p value
Daily Level						
H5: Stress		**Stress**				
Time	0.00	[−0.02, 0.02]	.86			
Time * Mindful Meditation	0.00	[−0.03, 0.03]	.97			
Time * Mindful w Choice	0.00	[−0.03, 0.03]	.90			
H6: Positive Mindset		**(A) Motivation**			**(B) Positive Affect**	
Time	−0.01	[−0.03, 0.01]	.29	0.02	[−0.00, 0.04]	.14
Time * Mindful Meditation	−0.02	[−0.06, 0.01]	.13	−0.04	[−0.07, −0.01]	.01*
Time * Mindful w Choice	−0.02	[−0.05, 0.01]	.14	−0.02	[−0.05, 0.01]	.13
H7: Decentering		**Decentering**				
Time	0.04	[0.02, 0.05]	<.001*			
Time * Mindful Meditation	−0.01	[−0.02, 0.01]	.52			
Time * Mindful w Choice	−0.01	[−0.03, 0.01]	.21			

The reference condition is Stress Mindset
* indicates significant values at an uncorrected p < .05 threshold

Description	Beta	95% CI	p value	Beta	95% CI	p value
H8: Choice & Stress		**Stress**				
Time	0.00	[−0.02, 0.02]	.72			
Time * Stress Mindset	0.00	[−0.03, 0.03]	.90			
Time * Mindful Meditation	0.00	[−0.03, 0.03]	.87			
H9: Choice & Positive Mindset		**(A) Motivation**			**(B) Positive Affect**	
Time	−0.03	[−0.06, −0.01]	.001*	−0.01	[−0.03, 0.01]	.52
Time * Stress Mindset	0.02	[−0.01, 0.05]	.14	0.02	[−0.01, 0.05]	.13
Time * Mindful Meditation	0.00	[−0.03, 0.03]	.94	−0.02	[−0.04, 0.01]	.30

The reference condition is Mindfulness with Choice
* indicates significant values at an uncorrected p < .05 threshold

Lastly, we hypothesized that the mindfulness with choice condition would demonstrate significantly greater improvements in stress reduction (H8) and positive mindset (motivation and positive affect; H9) compared to the mindfulness meditation and stress mindset conditions. However, no significant effects of the mindfulness with choice condition were observed on either of these variables (Table 1).

Discussion

The present study investigated whether the proposed mental health interventions were adaptable to online formats to improve student coping and well-being during the pandemic. Another aim of the study was to examine whether the web-based training models would be effective enough to improve students' decentering and reappraisal skills within three weeks. Our pre-registered
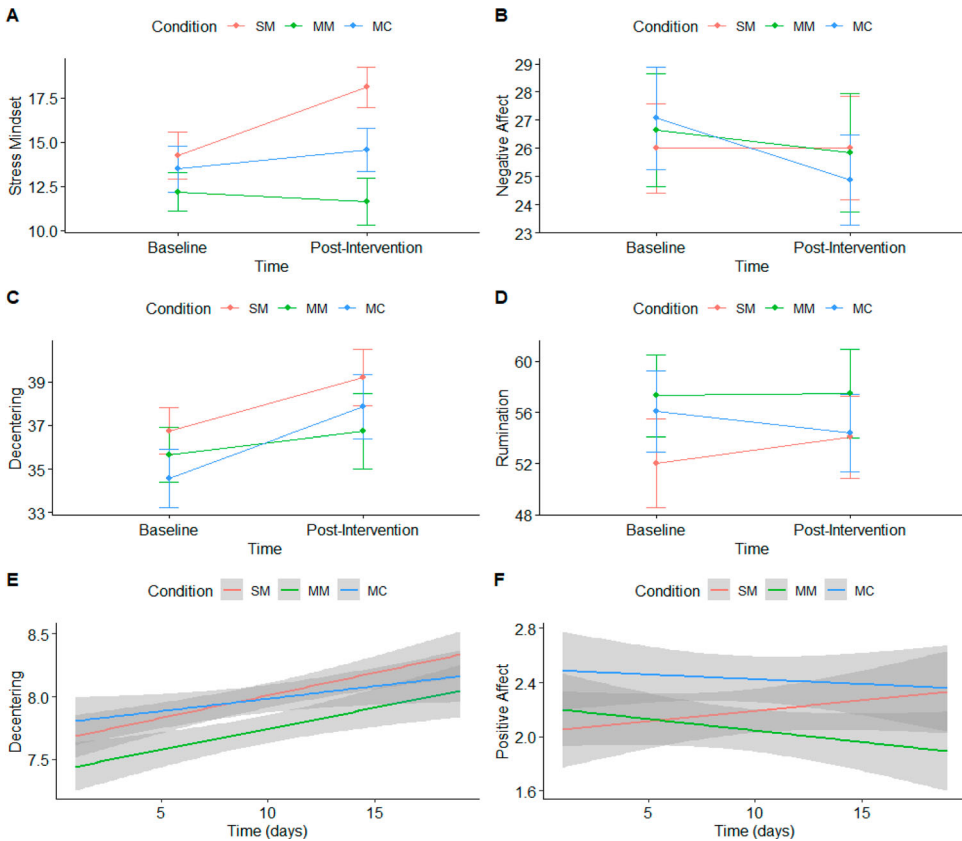
Figure 2. Intervention-specific effects on primary outcome variables. Error bars and shaded areas represent standard errors. The top two panels show baseline to post-intervention effects, while the bottom panel shows daily effects. SM = Stress Mindset, MM = Mindfulness Meditation, and MC = Mindfulness with Choice conditions.

hypotheses were partially supported: the two mindfulness groups showed no advantages in improving stress, positive affect, decentering, or positive reappraisal compared to the stress mindset group at both the study and daily level. However, the mindfulness with choice condition significantly decreased negative affect and rumination compared to the stress mindset condition at the study level. The selective effects of the mindfulness interventions on only negative mood and coping strategies align with previous research (May et al., 2020; Perestelo-Perez et al., 2017; Schroevers & Brandsma, 2010). Additionally, the lack of significant reduction in stress is surprising considering the well-documented positive effects of mindfulness and stress reappraisal training (Huebschmann & Sheets, 2020; Krusche et al., 2012; Mak et al., 2015). One explanation for this lack of benefit may be that participants were undergoing increasing perceived stress over the study period (Pitt et al., 2018), as students enrolled in the study at the beginning of the semester and completed their participation around midterm examinations. By including a control group in future studies, we would be able to demonstrate the effects of web-based mindfulness and stress reappraisal training on stress reduction.

All conditions demonstrated improvements in decentering at the daily level (3 sessions per week) and the study level (baseline and post-intervention). However, no conditional differences were found, which might be attributed to the fact that all conditions implemented active training interventions that could improve students' decentering skills (Crum et al., 2013; Farb et al., 2007, 2013). When comparing mindfulness with choice condition to both stress mindset and mindfulness meditation condition, it seems that our incorporation of training choice was effective at decreasing

both negative affect and rumination at the study level, which further supported our hypothesis that including choices is beneficial for keeping or even increasing people's motivation and engagement (Merrill, 2002; Reeve et al., 2003). Surprisingly, the stress mindset condition did not increase positive reappraisal significantly, perhaps due to stress mindset training engaging a different level of emotion regulation. Stress mindset training targets *secondary appraisals*- ideas of resilience and the ability to cope following a stress appraisal, while positive reappraisal may indicate changing one's *primary appraisals* to focus on positive aspects within a stressful situation (Kilby & Sherman, 2016).

Overall, based on the current findings, it seems that students' mental health and coping strategies were supported by brief online interventions. This study was also designed to investigate whether brief web-based mental health interventions were tolerable and helpful for improving undergraduates' well-being and regulation skills. A total of 233 students signed up during the baseline survey (stress mindset = 77, mindfulness meditation = 77, mindfulness with choice = 79) and 177 (stress mindset = 58, mindfulness meditation = 56, mindfulness with choice = 63) completed the study with an overall retention rate of 76%. The dropout rate among each condition was different with the mindful meditation condition having a slightly higher dropout rate (27.27%) compared to both stress mindset (24.67%) and mindfulness with choice (20.25%), which could also imply that including choice for mindfulness trainings could keep or improve students' participation and engagement during the three-week interventions. One thing that needs to be noted is that during the post-study survey some participants commented that they hoped the links for training and check-in sessions could be longer than 24 h. In our future studies, we plan to extend the training link availability till the next training session (i.e., available for 72 h) so participants would have more flexible time to practice.

Limitations and future directions

As alluded to above, one limitation of the current study was that we did not include a control group to help clarify our current findings. The reason for not including a control group was that we primarily aimed to compare the effectiveness of three validated mental health interventions in online settings and to support students' mental well-being during the pandemic. We did not consider including a control condition where students would receive no benefits for three weeks. However, given the positive outcomes of this study, future research should include a control group to better distinguish training effects from changes that would occur naturally over the school term. Participants could participate in the control condition that matches the time spent in the intervention conditions but involves only brief report on stress and well-being, and then allocates the remaining time towards simple video games (e.g., Tetris) in lieu of mindfulness or stress mindset training. Following study participation, all participants could still be given opportunities to enroll in other preferred conditions using a waitlist control design.

Another adaptation suggested for future interventions is to focus on the mindfulness with choice style of mindfulness training over a fixed curriculum. Our incorporation of training choice appears to bring greater positive changes in positive affect, motivation, and decentering at the daily level, which supports our hypothesis that including choices is beneficial for keeping individuals engaged. To promote greater advantages for the mindfulness condition in increasing decentering compared to stress reappraisal training, instead of practicing various mindfulness content (e.g., present moment, willingness, value), we suggest focusing primarily on present moment awareness and acceptance exercises.

Third, given the success of the mindfulness and stress mindset interventions, future research might combine these conditions to see whether a hybrid condition is more than the sum of each part. Mindfulness-to-Meaning Theory (MMT) states that changes in decentering predict changes in reappraisal, which could lead to higher levels of well-being and meaning in life (Garland et al., 2015). Based on our current findings, the mindfulness with choice condition increased both decentering and stress mindset without receiving specific reappraisal training, which supported the first

part of MMT. Therefore, by including the mindfulness with choice condition, the stress mindset condition, and a combined condition in future studies, we could test MMT in a new way that has not been done before: the overall pathway from decentering to reappraisal to well-being. We would determine whether decentering promotes reappraisal, and if this would lead to a greater sense of *meaning* in life, contributing powerfully to well-being.

Finally, a reliance on participant self-report is perhaps the most important indicator of mental health, but the reliability of such reports could be improved by incorporating mixed-methods into future research, such as peer evaluations of well-being, academic performance indicators such as grades, and passively-acquired smartphone data around technology use and mobility. Nevertheless, a promising initial indicator of any mental health intervention must begin with self-report, and the present findings serve as a foundation for more complex multi-method research.

Concluding remarks

The present study supports the effectiveness of brief web-based mental interventions for university students during the pandemic. With the majority of participants reporting high levels of stress and anxiety symptoms, and a third reporting depression symptoms, there is an urgent need to develop new coping strategies and support student mental health. While symptoms and mood were not significantly impacted by the interventions, both mindfulness and stress mindset training reliably increased coping skills such as decentering, with an additional benefit to promoting a resilient stress mindset in the stress mindset condition. In prior work, growth in decentering rather than the elimination of affective symptoms was protective against mood disorder vulnerability (Segal et al., 2019), and so it appears that these interventions may address future vulnerability even if they do not directly promote more positive mood states. As such, brief online training interventions may provide alternative coping strategies for students to better adapt to unavoidable stressors inherent in their academic careers.

Disclosure statement

Data availability statement

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

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