A Longitudinal, Randomized and Controlled Study of App-delivered Mindfulness in the Workplace

Jennifer S. Mascaro, MD^{1*}, Kathryn Wehrmeyer, BS¹, Veronica Mahathre, MPH¹, Alana Darcher, BS¹

Abstract

Introduction: Workplace mindfulness meditation programs are of great interest for improving employee well-being and job performance, fueled in part by the apparent effectiveness of mindfulness meditation as well as by the recent proliferation of mobile mindfulness applications (apps) that can be incorporated into a workplace setting. It is critical to examine the facilitators and barriers to engaging with app-delivered mindfulness in the workplace to understand how biological, psychological, and socio-demographic variables impact practice time.

Methods: Using a longitudinal and randomized controlled design, we explored facilitators of and barriers to practicing app-delivered mindfulness in the workplace among predominately non-white call center employees. Mindfulness engagement was operationalized as practice time during a prescriptive study period as well as during the entire 1-year duration of the app subscription. In addition, we made preliminary estimates of the impact of app-delivered mindfulness, compared to wait-list open relaxation, on job performance, negative symptoms, well-being, and social connectedness.

Results: Employee C-reactive protein levels were positively correlated with subsequent meditation practice time. Employees who reported wanting to use the app to manage stress were most likely to use it, and women practiced significantly more than men. No other psychological resources were significantly correlated with practice time. Employees randomized to mindfulness had a significant increase in self-reported mindfulness scores, but did not have significant improvements in any other psychological or performance domains.

Conclusion: Together these data expand what is known about engagement with, and impact of, mindfulness on a population that is under-represented in the research on mindfulness meditation.

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Affiliations:

¹Emory University School of Medicine, Department of Family and Preventive Medicine

INTRODUCTION

Since first popularized in clinical and therapeutic domains and operationalized as the intentional, non-judgmental awareness of moment-to-moment experience [1, 2], the last two decades have seen an exponential rise in research on mindfulness meditation. Recent meta-analyses indicate that mindfulness meditation interventions may be effective for enhancing well-being [3], reducing anxiety and depression [4], and optimizing immune physiology [5] and daily functioning [6]. Other research indicates that mindfulness has beneficial effects on attention and cognitive performance [7], and that trait mindfulness is linked with personal and professional flourishing [8].

With its popularity and apparent effectiveness in optimizing health, well-being, and cognitive function, it is not surprising that mindfulness programs are of great interest as a preventive intervention for managing stress and well-being at work [9-12]. Mindfulness in the workplace has become more tractable with the development and popularity of mobile application [app]-delivered meditation content, available both in the public (i.e. free) and consumer domain. While mobile technology applied to health promotion has the potential to prevent disease and reduce health disparities, there is relatively little rigorous empirical research to accompany the growth of this health technology [13]. However, a recent spate of research indicates that app-delivered mindfulness meditation reduces self-reported stress, irritability [14],

depression [15], burnout, and compassion fatigue [16], and attenuates the cortisol response to a psychosocial stress test compared to active control conditions [17]. App-based programming may prove particularly important for workforce populations with extreme time demands [16] and for more rural and blue-collar workforces, which have lower rates of access and engagement with workplace mindfulness programming [18], and which present unique challenges for workplace well-being (e.g. [19]).

Despite the apparent promise of app-delivered mindfulness, less research has been conducted to examine who engages with mindfulness apps and how demographic characteristics or individual variation predict practice time, especially in the workplace [20]. This research gap is of great interest given a wealth of research indicating that the effects of mindfulness are reliant on and commensurate with time spent practicing [21-26]. While not all studies find a direct correlation between mindfulness practice time and outcomes, a large body of research indicates that "on the cushion" practice time, rather than non-specific effects or simply learning mindfulness concepts, mediates the effects of mindfulness interventions [26, 27]. Qualitative research points to logistical or practical barriers to meditation practice, such as the prohibitive time commitment; [28] however, few studies have examined the facilitators and barriers to meditation practice, especially app-delivered meditation.

*Correspondence To: Jennifer S. Mascaro
Email: jmascar@emory.edu

As mindfulness proliferates beyond the biomedical contexts and populations in which it has been traditionally popular within modern Western contexts, it is crucial to examine its acceptability and gain an understanding of the personality and demographic variables that predict engagement. While it is clear from previous research that engagement with mindfulness varies based on demographic [18, 29] and individual differences [30], a challenge of interpreting these data is understanding causal mechanisms that render meditation accessible and acceptable to some populations and not to others. This is a particularly obfuscating challenge, since previous research points to logistical or practical barriers to meditation practice, including time commitments [28], and lack of access [18]. To overcome this challenge, the current study was designed to provide 1-year subscriptions to a popular mindfulness meditation app and to reduce logistic barriers by providing employees with a break to use the app. In addition, we examined the impact of app-delivered mindfulness on both self-reported and job performance outcomes.

The study had two specific aims. First, we designed the study to examine facilitators of and barriers to practicing app-delivered mindfulness in the workplace. To address this aim, we used a biopsychosocial framework toward a holistic and whole-person approach to workplace wellness and lifestyle medicine [31, 32]. We tested the hypothesis that psychological resources and sociodemographic factors would predict engagement with the app. We also tested the hypothesis that biological factors would influence app use. Specifically, we examined whether inflammatory states or self-reported sleep disturbance predicted practice time, since previous research indicates that both of these variables are likely to impact the ability to engage in an intervention [33–35]. Second, we evaluated the impact of app-delivered mindfulness, compared to wait-list open relaxation, on job functioning, daily functioning, well-being, and social connectedness.

METHODS

Study Overview

To investigate the facilitators of and barriers to engagement with a mindfulness app, as well as the effects of app-delivered meditation training in a workplace environment, this study used a longitudinal, randomized, and controlled design in which two cohorts of participants were randomized to either 6 weeks of daily mindfulness practice delivered by the Headspace app (<https://www.headspace.com/>) or to an open relaxation group that was instructed to relax any way they would like. The study was conducted in the Emory Healthcare Patient Access Center, a high-volume call center that serves as the primary point of contact for patients, families, referring providers, clinical and non-clinical staff. Employees provide general scheduling, registration, messaging, and customer service duties, and they are expected to adhere to a monitored schedule for 100% of the workday. Employee study participants were recruited via face-to-face presentations conducted at the monthly organizational “Town Hall” meetings and subsequent emails. All Patient Access Team employees (n = approximately 220 employees) were invited to participate. Interested employees attended a consent and assessment session where signed informed consent was obtained from all participants after a full description of study procedures and risks and potential benefits, and prior to conducting any study procedures.

Prior to randomization and upon completion of the program, participants completed measures of psychosocial resources, negative symptoms, and well-being. The

first cohort (n = 53) of participants provided a saliva sample for the measurement of C-reactive protein (CRP). To reduce participant burden, we did not collect saliva samples from the second cohort of participants. In addition, supervisors blind to study participation rated call performance during 6 randomly selected calls per month. Facilitators and barriers to practice were examined within a biopsychosocial model in order to examine the biological, psychological, and social factors that impact engagement with app-delivered mindfulness meditation in the workplace. We quantified practice time at two different time points, namely, during a 6-week prescriptive time period in which study participants who were randomized to practice mindfulness were asked to practice for 10 minutes each workday, and during a 1-year period of time when all participants were able to use the app as much as they wanted. Finally, we examined the impact of 6 weeks of mindfulness by comparing changes in well-being among employees randomized to mindfulness with changes in employees randomized to open relaxation.

Participants

Participants were recruited from the Emory Healthcare Patient Access Team via optional presentation and emails over two separate cohorts. There were no exclusion criteria. Participants (n = 95; 85 female) were between the ages of 23 and 65 (M: 36.2 SD: 10.9). Enrolled participants were provided a 12 minute break each workday. Employees randomized to Headspace (n = 48) were asked to meditate for 10 minutes each day for 6 weeks, whereas individuals randomized to the open relaxation group (n = 47) were asked to relax any way they would like. Three participants randomized to the open relaxation group accessed the app during the study period and for this reason were excluded from all analyses with the exception of the entire group analysis of predictors of 1-year practice. There were no significant differences between the groups for sex/gender, race, or age. Prior to the intervention, performance ratings and self-reported depression were significantly different between the groups due to chance (Table 1).

Table 1: Demographic and pre-randomization (Time 1) performance and self-reported characteristics of study participants randomized to the app and relaxation groups.

	App	Relax	p-value
Sex/gender	42 F, 6 M	43 F, 4 M	0.53
Race			0.24
	American Indian	1	0
	White	7	4
	African, African-American	33	40
	Asian	1	2
	Other	5	1
Age	35.7 (10.2)	36.7 (11.8)	0.67
Month 0 (pre-study) performance	82.9 (13.7)	88.6 (9.05)	0.04*
Sleep	8.10 (3.64)	7.03 (2.98)	0.16
Depression	5.72 (5.43)	3.39 (4.07)	0.03*
Anxiety	4.76 (5.44)	4.17 (5.98)	0.63
Stress	10.13 (7.32)	7.95 (6.15)	0.14
Mindfulness (FFMQ total)	133.5 (18.1)	141.4 (23.6)	0.14
Perceived social support	27.2 (7.93)	28.0 (8.56)	0.69
Salivary CRP	591.0 (570.6)	638.8 (587.2)	0.79

*Significant at the 0.05 level (2-tailed).

Biological Variables

We measured self-reported sleep using the Pittsburgh Sleep Quality Inventory [36], as well as salivary C-reactive protein (CRP). We acquired saliva from study participants at the same time of day using passive drooling into a polypropylene tube.

Psychological Resource Variables

We measured psychological resources using the following self-report measures: Brief Self-Control Scale (BSCS) [37], General Self-Efficacy Scale (GSES) [38], The Depression Anxiety and Stress Scale (DASS) [39], and the Five Facet Mindfulness Questionnaire (40) scale, the most commonly used mindfulness questionnaire in research on workplace mindfulness [20].

In addition, we administered an interest survey that used a 7-point Likert scale to query participants' overall interest in using the app, their interest in using the app to 1) manage stress, 2) improve personal relationships, 3) improve physical health, or 4) improve their mental health. We also asked participants to indicate whether they were primarily interested in participating: 1) to advance scientific research, 2) for the compensation, and 3) because they felt like they were supposed to.

Sociodemographic Variables

We measured social support using the Interpersonal Support Evaluation List (ISEL) [41]. In addition, we collected the following self-reported demographic variables: sex/gender, race/ethnicity, and age.

Performance

The Agent Performance Program was implemented at the start of fiscal year 2016 to assess employees' job performance. Performance is based on call ratings (80%, described below) and schedule adherence (20%, described below), and determines employee bonus and recognition. The overall scoring scale is as follows: 100-96: "Commendable"; 95-91: "Exceeds expectations"; 90-85: "Fully meets expectations"; 84-80: "Needs improvement"; < 80: "Does not meet expectations". The performance program is independent from the current study and thus all raters were blind to employee participation status and to the goals of the study.

Mindfulness Meditation App

Participants randomized to the mindfulness group were provided a 1-year subscription to Headspace (<https://www.headspace.com/>), a popular mindfulness meditation app that has over 20 million worldwide downloads [14] and which has been highly rated in content evaluations [42]. Participants randomized to the app group were instructed to complete the 10-minute version of levels 1, 2, and 3 of the Foundation series during their 12 minute break each day. These series introduce the concepts of mindfulness (e.g. equanimity) and include meditations centered on breath- and body-based mindfulness, mindfulness toward sounds in the environment, and mindfulness toward the contents of the mind. Participants were instructed that they could use the app at home and on the weekends in addition to workplace use. After the prescriptive 6-week period, all participants were provided a 1-year subscription to the app.

We used app usage data as a measure of mindfulness practice and quantified use during 2 time periods: (1) during the 6-week prescriptive period in which participants randomized to Headspace had the app, and (2) during the 1-year free period in which all study participants had access to the app. Compliance was defined as completing at least 150 minutes of meditation during the 6-week study period.

Statistical Analysis

Descriptive statistics were used to characterize all biopsychosocial variables, as well as for practice time for the

two intervals of interest (i.e. the 6-week prescriptive study period and the 1-year subscription period). Missing items in the psychometric scales were estimated with expectation maximization [43] (when missing at random, evaluated using Little's MCAR test) using other items within the scale as predictor variables. Missing values were not estimated for participants missing more than 20% of items for an individual scale, and instead those participants were not entered into that analysis. Independent t-tests were used to evaluate randomization success; that is, to evaluate whether there were significant differences between the groups at baseline. In order to interrogate the relationship of biopsychosocial variables with app-use during the two intervals, we conducted Spearman's rho correlation analyses to test whether any continuous variables were correlated with practice time. Independent t-tests and one-way ANOVAs were used to test whether categorical demographic variables predicted practice time. To evaluate the impact of app-delivered mindfulness, we conducted repeated measures ANOVAs to compare changes in self-reported well-being (depression, anxiety, stress, sleep, perceived social support, and mindfulness) and employee performance ratings for participants randomized to the mindfulness app compared to participants randomized to the free relaxation group. For any variables that demonstrated a significant difference by group at baseline (prior to randomization) we conducted linear regression analyses to evaluate whether the group assignment accounted for significant variance in post-intervention scores, controlling for pre-intervention (i.e. baseline) scores. Analyses were conducted using IBM SPSS 24.

RESULTS

Overall App Use

Employees randomized to mindfulness practiced between 0 and 462 minutes (M: 119.8; SD: 135.9) during the 6-week prescriptive period. Eighteen employees (36.7%) practiced at least half of the suggested amount (i.e. 150 minutes or more) and were considered compliant, and 6 employees (12.2%) practiced the recommended 300 minutes or more. Fourteen participants (15.2%) randomized to mindfulness did not use the app at all, and 5 (5.4%) tried only a single session. Overall, employees practiced between 0 and 1813 minutes (M: 109.7; SD: 249.7) during the 1-year period. Fifty-six study participants (58.9%) did not use the app at all. Twenty-one participants (22.1%) practiced at least 150 minutes during the 1-year subscription period.

Biological Facilitators and Barriers to Practice

With respect to our first aim of identifying biopsychosocial barriers and facilitators of practice, bivariate correlation analyses indicated a significant positive correlation between salivary CRP levels and study practice time: ($r(22) = 0.60, p = 0.002$). To ensure that this finding was not confounded by the well-characterized sex difference in inflammatory bio-markers [44, 45] (i.e. that there was a sex/gender effect on practice time and women tend to have higher levels of salivary CRP), we looked to see whether this correlation was significant within only the female study participants and it was: ($r(18) = 0.61, p = 0.004$). There was not a significant correlation between 1-year practice time and salivary CRP levels ($r(45) = 0.09, p = 0.54$). Nor was there a significant correlation between sleep and either practice time measure (Study: $r(40) = -0.01, p = 0.94$; 1-year: $r(80) = -0.04, p = 0.74$).

Table 2: Spearman's rho correlations between study practice time, one-year practice time and self-reported interest and non-meditation interests.

	I want to use the app to...				I joined the study...		
	manage my stress	improve personal relationships	improve physical health	improve mental health	help advance science	compensation	felt pressured
Study period (n = 49)	0.34*	-0.09	0.02	-0.06	-0.28*	-0.20	-0.34*
One year (n = 95)	0.33**	0.11	0.19	0.09	-0.01	-0.00	-0.06

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Psychological Facilitators and Barriers to Practice

Next, we examined whether practice time was correlated with psychological resources or with motivational, social, or demographic factors. Neither study practice time nor 1-year practice time were significantly correlated with any psychological attributes, including self-control (Study: $r(38) = 0.25$, $p = 0.13$; 1-year: $r(76) = 0.18$, $p = 0.12$), mindfulness (Study: $r(34) = 0.23$, $p = 0.17$; 1-year: $r(76) = 0.11$, $p = 0.38$), or self-efficacy (Study: $r(40) = -0.12$, $p = 0.46$; 1-year: $r(78) = -0.00$, $p = 0.97$). Nor was practice time related to negative psychological factors: depression (Study: $r(45) = -0.11$, $p = 0.47$; 1-year: $r(88) = 0.12$, $p = 0.28$), anxiety (Study: $r(45) = -0.02$, $p = 0.91$; 1-year: $r(88) = 0.11$, $p = 0.32$), or stress (Study: $r(45) = -0.08$, $p = 0.61$; 1-year: $r(88) = 0.08$, $p = 0.48$).

Social Facilitators and Barriers to Practice

Study practice time was not correlated with overall interest in using the app, but it was positively correlated with self-reported interest in using the app to help manage stress ($r(47) = 0.34$, $p = 0.015$). One year practice time was positively correlated with both overall interest in using the app ($r(93) = 0.29$, $p = 0.005$) and with interest in using the app to help manage stress ($r(93) = 0.33$, $p < 0.001$). Study practice time was inversely correlated with non-meditation interest: $r(47) = -0.36$, $p = 0.01$. This effect was primarily driven by participants' answers to the individual items, "I am primarily interested in participating because I felt like I was supposed to" ($r(47) = -0.34$, $p = 0.015$) (Table 2). Neither study practice nor 1-year practice time were significantly correlated with participant age (Study: $r(46) = 0.08$, $p = 0.57$; 1-year: $r(92) = 0.10$, $p = 0.32$). Female participants practiced significantly more than male participants for both time spans: (Study: degrees of freedom adjusted based on significant Levene's Test of Equality of Variances, $t(26.7) = 4.03$, $p < 0.001$; 1-year: $t(92.6) = 3.46$, $p = 0.001$). There was not a significant difference in either practice time outcome based on race.

Impact of Mindfulness

To examine the impact of app-delivered mindfulness, we conducted repeated measures ANOVAs to evaluate whether participants randomized to the app had significant changes in job performance and self-reported negative symptoms and well-being compared with those randomized to wait-list relaxation (Table 3, next page). Participants randomized to Headspace, compared to those randomized to open relaxation, did not have a significant change in sleep [$F(39) = .446$, $p = 0.51$]; salivary CRP [$F(23) = .93$, $p = 0.35$]; anxiety [$F(43) = .48$, $p = 0.49$]; stress [$F(43) = .69$, $p = 0.41$]; or perceived social support [$F(36) = 2.25$, $p = 0.14$]. Nor did group assignment account for variance in post-intervention depression

or objective performance scores, controlling for pre-intervention values. Participants randomized to the app group, compared to those randomized to relaxation, had a significant increase in self-reported mindfulness ($F(29) = 4.25$, $p = 0.048$), an effect that was driven by the Act with Awareness subscale: $F(30) = 12.22$, $p = .001$. These effects were unrelated to practice time or compliance.

DISCUSSION

The current study examined predictors of engagement with app-delivered mindfulness meditation in a workplace environment. Participants were majority non-white employees in a large, urban healthcare call center. Because all employees enrolled in the study were provided a 12-minute break to use the app, this study design removed one common barrier to practice, a lack of time. However, practice time still varied among the group randomized to use the app. App-use during the prescriptive, 6-week study period was positively correlated with salivary CRP levels, but not significantly related to self-reported psychological resources such as self-control or self-efficacy. Nor was practice time correlated with negative symptoms or sleep. Practice time was inversely correlated with self-reported interest in non-meditation aspects of the study, particularly the extent to which the employee reported feeling like they were supposed to participate. Women practiced significantly more than men; however, there were no differences in practice time based on race or age.

These findings are consistent with research from clinical and counseling psychology, which indicate that motivation predicts adherence to psychotherapy and to other behavioral health programs, such as those for smoking cessation [46] and alcohol [47] and diabetes self-management [48] programs. Interestingly, self-reported impulse control, self-control, and self-efficacy did not predict practice time, warranting further thought. Recent meta-analytic research indicates that self-reported self-control is less predictive of controlled behavior (compared to automatic behavior) [49], and an emerging theoretical model questions the importance of effortful self-control in understanding goal pursuits and positive outcomes [50]. Interestingly, self-reported enthusiasm for practicing mindfulness to reduce stress was positively correlated with practice time during the study period and over the entire year. Together, these findings suggest that self-reported motivation to engage in behavior changes targeted toward specific psychological symptoms is a better predictor of engagement with mindfulness meditation than are psychological resources. This is broadly consistent with research on the importance of "want-to" motivation, in contrast to effortful self-control, for self-regulation and health behavior [51, 52]. Of note, the

Table 3: Post-intervention ANOVAs evaluating self-reported well-being, employee performance, and salivary CRP between mindfulness app and free relaxation groups

	<u>App Mean</u> (SD)	<u>Relax Mean</u> (SD)	<u>Mean Square</u>	<u>F</u>	<u>p-value</u>
Time 2 Sleep	6.90 (3.24)	6.35 (3.33)	1.9	0.45	0.51
Time 2 Anxiety	3.29 (3.46)	1.65 (2.81)	7.59	0.48	0.49
Time 2 Stress	6.00 (5.46)	4.78 (4.56)	12.52	0.69	0.41
Time 2 Mindfulness (FFMQ total)	135.6 (25.0)	139.6 (18.4)	374.2	4.25	0.05*
Time 2 Mindfulness -Awareness	29.3 (6.32)	29.1 (5.27)	85.32	12.22	.001**
Time 2 Perceived social support	29.3 (7.67)	26.6 (7.98)	26.21	2.25	0.14
Time 2 salivary CRP	623.5 (804.2)	252.7 (117.4)	73,770	0.93	0.35
			<u>Standardized</u> <u>Beta</u>	<u>t</u>	<u>p-value</u>
Month 3 (post-study) performance	84.7 (18.3)	86.9 (9.04)	0.04	0.29	0.77
Time 2 Depression	3.88 (5.83)	1.35 (1.87)	-0.15	-1	0.32

** Significant at the 0.01 level (2-tailed).

* Significant at the 0.05 level (2-tailed).

Footnote: Participants were randomized to the mindfulness app or the free relaxation group. Changes in performance and depression by group are evaluated with a linear regression model, as the groups were significantly different at baseline.

participants in this study were not experienced meditators, and this finding may not generalize to populations that have extensive meditation experience. A recent study found that a majority of yoga practitioners report changes to their primary motivation for practice. While most study participants reported that they began yoga for exercise or stress relief, 61% reported a change in their primary reason or new motivations to practice yoga [53].

In addition, participants with higher levels of CRP at the beginning of the study were more likely to practice mindfulness meditation. CRP is a sensitive marker of systemic inflammation that can be reliably measured in saliva, and chronic low-grade inflammation is an independent risk factor for cardiovascular disease, type 2 diabetes, and other chronic diseases [54, 55]. While important, this finding is not necessarily consistent with previous research. A large body of work supports the role of chronic, low-grade inflammation in fatigue [56–58] and mood disorders [59]. Moreover, inflammation affects motivation [34] and cognitive function [60] and thus may influence whether someone is able to engage in or benefit from an intervention. For example, one study found that patients with high levels of inflammation prior to bariatric surgery had less weight loss after the surgical intervention [61]. While we hypothesized that participants with high levels of salivary CRP would engage less with mindfulness meditation, we found the opposite pattern. It is not clear whether these results indicate that CRP levels are predictive of mindfulness engagement in general, but we believe it is unlikely that CRP levels had a mechanistic influence on meditation practice. Rather, together with the self-reported desire to reduce stress, we interpret this finding to indicate that participants who used the app the most were those that stood the most to gain from it. Whereas several studies have used national databases to examine why people use meditation [62, 63], few longitudinal studies have examined this question from the perspective of biomarkers of stress physiology or illness. Most longitudinal research study designs afford the ability to examine this question, and going forward it will be important to continue to examine whether people who practice mind-body interventions are those that have the most physiological or clinical need for them.

The proliferation of mindfulness within biomedical contexts arises concomitant with increased attention toward workplace well-being and mental health, as mental

health problems among employees are costly in terms of both participation rates and lost productivity [64]. Moreover, deleterious psychosocial working conditions are a clear risk factor for the development of common mental health problems [65], and preventive measures to mitigate these risks are well-established to reduce the burden of negative mental health symptoms among employees [64]. Trait mindfulness has been positively associated with job satisfaction, employee relationship quality, workplace performance, and inversely correlated with burnout [8]. A recent survey conducted by the Center for Disease Control found increased prevalence rates for mindfulness programs in the workplace, and estimated that 1 in 10 white-collar employees have engaged in mindfulness practices at work [18]. The majority of these published studies (estimated 81%) examined the impact of mindfulness programs on stress among employees, and mindfulness-based stress reduction (MBSR) was the most commonly studied mindfulness intervention [20].

While mindfulness is increasingly offered in the workplace environment, few studies have included objective workplace performance or measures related to stress physiology and the majority of research studies have examined MBSR programs. Here we examined the impact of app-delivered mindfulness, compared with an open relaxation control group. Participants randomized to Headspace reported significantly increased levels of mindfulness, primarily driven by increases in self-reported Act with Awareness. Changes in mindfulness were not correlated with practice time, nor was there a significant difference in change scores for participants who complied (defined as completing at least 150 minutes of meditation during the 6-week study period). However, there was no other significant impact of app-delivered mindfulness on any of the outcomes measured.

It is worth reflecting on the lack of significant effects of mindfulness on negative symptoms and workplace performance. Of note, another recent study of app-delivered mindfulness found that participants randomized to mindfulness did not have self-reported benefits, but exhibited a significantly attenuated stress response to a social stress test [17]. These findings highlight the importance of multi-method approaches to studying the impact of meditation and are consistent with the current findings indicating that some self-reported negative symptoms may be more intractable to

app-delivered mindfulness interventions. Moreover, it is clear that workplace mental health interventions are most effective when they are holistic and comprehensive [66]. In the current study, the program arguably promoted mental health by cultivating mindfulness; however, more global effects on depression, and anxiety may require the direct address of work-related risk factors. Similarly, online occupational mental health interventions appear to be most effective when they are multi-modal, for example combining online content with text-message reminders [67]. This may be particularly true with online workplace mindfulness programs. For example, a large, multi-arm study found that employees access online content twice as much if they were also provided group support [68]. While employees in the current study were provided a structured break for mindfulness practice, we did not prompt them with reminders or include any group or motivational content.

Further reflecting on the null findings, there is an apparent need for critical examination of the fidelity and integrity of mindfulness interventions. Does app-delivered mindfulness have the key elements necessary to qualify as a mindfulness intervention? This will be an especially important question moving forward, as the proliferation of meditation apps in the consumer domain will raise new challenges for program adherence and for understanding intervention fidelity. For example, by some accounts, the relational didactic interaction between the participant and an instructor is an essential feature of a mindfulness based program [69]. A recent study comparing the impact of app-delivered mindfulness with a traditional mindfulness intervention for pediatric nurses found that app-delivered mindfulness (Headspace) was marginally more effective in reducing burnout, but that traditionally delivered mindfulness was more effective for nurses with a history of trauma [16]. More fine-grained and thorough analyses of population-specific benefits from group-delivered versus app-delivered contemplative content is critical to understanding the public health applications of meditation and of mobile health technology more broadly.

The current study had several notable strengths. First, the workplace population was comprised primarily of non-white employees, and thus expands what is known about the impact of mindfulness on a population that is under-represented in the research on mindfulness meditation. Second, the study design included several components identified as important for online occupational well-being programs, including guided content and the use of tunneling (leading participants through a sequence of content), the ability to self-monitor, and tailoring of the workplace environment to facilitate engagement (in this case, carving out specific practice time) [20, 67]. In addition, this study used an intent-to-treat design and an active control group to examine both self-reported outcomes as well as objective performance ratings, features that are uncommon among studies of workplace mindfulness and of mindfulness more generally [20, 70]. Finally, we tracked app-use for a 12 month period of time to examine predictors of practice in order to contribute novel data toward an understating of who and why individuals practice mindfulness meditation.

LIMITATIONS

While the study design and resultant data generate new knowledge about mindfulness in the workplace, there are some limitations of these data. First, the study may have

been underpowered to discern relationships between biopsychosocial facilitators to mindfulness practice or to detect effects of mindfulness practice. With respect to the latter aim, a relatively large number of participants were lost to the Time 2 assessment, leaving approximately half the original enrollees in our intent-to-treat analyses. Future studies conducted with larger employee populations will be important to determine whether these results are replicated. It is important to note that the findings presented here come from a non-clinical population, and may not generalize to clinical populations, whom previous research indicates may have unique challenges engaging with mindfulness (71, 72). Similarly, while the current study examined solitary app-based mindfulness, it is not clear whether these findings generalize to group mindfulness programs, which likely provide a qualitatively different experience (28). In addition, because enrollment into the study was voluntary, there was likely a selection bias such that the study participants are not representative of the entire employee population. In fact, the majority of participants reported being interested in using the app and very few reported feeling pressured. If all employees had felt implicitly pressured or explicitly mandated to join the study, the population and observed effects of the intervention would likely be different. Finally, we did not collect demographic information about education level or socioeconomic status, and thus were unable to examine whether these factors influenced app-use.

There is a great need for rigorous research to inform best approaches for recruitment and incentivization of workplace mindfulness programs. Future work should continue to address the critical dual questions of who practices and who benefits from mindfulness training in diverse contexts, with diverse delivery modalities, and among diverse study participant populations. Ultimately, these findings help inform questions around empowering, motivating, and sustaining behavior change and lifestyle approaches to wellness. Future research should examine whether motivational interviewing could be used to increase engagement with mindfulness meditation and other mind-body approaches to health and stress management [73], and findings from this study indicate that increasing the motivation to reduce stress may improve adherence to mindfulness-based interventions.

CONCLUSION

This study expands what is known about engagement with, and impact of, app-delivered mindfulness meditation in a population that is relatively underrepresented in current research on meditation. Despite a study design the removed many of the usual barriers to engagement, the results revealed variation in app-use that was best predicted by self-reported interest in practicing mindfulness in order to manage stress. While employees randomized to use the app reported a significant increase in mindfulness, the lack of significant improvements in any other psychological or performance domains suggest that app-delivered mindfulness programs in the workplace may require more extensive and supportive programming to confer benefits.

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