

A Cross-Sectional and Longitudinal Study of the Effects of a Mindfulness Meditation Mobile Application Platform on Reducing Stress and Anxiety

Abstract

Introduction: The development of many lifestyle-related chronic disorders occurs as a result of stress and anxiety. In recent years, in order to overcome lifestyle-related problems, people are increasingly making use of mindfulness meditation mobile applications despite the fact that there is no substantial evidence that this practice has benefits for their health. **Aim:** Testing the effectiveness of this method in reducing stress and anxiety through the development of a mindfulness meditation mobile application was the aim of this project. **Methodology:** Two independent studies were conducted. For both the studies, IBM SPSS Statistics 23.0 software was used to perform the statistical analysis. The first study was conducted cross-sectionally between 111 meditators and 111 non-meditators. The use of Depression, Anxiety, Stress Scale (DASS) was employed in assessing the stress and anxiety. It was found out that stress ($P < 0.000$) and anxiety ($P < 0.000$) are significantly reduced for meditators in comparison with the non-meditators. A substantial reduction was observed using the cross-sectional study, and a longitudinal study was carried out to affirm the effectiveness of this method in reducing stress and anxiety. 67 users were shortlisted for the study and their stress and anxiety level was measured before and after practicing mindfulness meditation. **Result:** The result revealed that there was a substantial reduction in stress ($P = 0.01$) and anxiety ($P = 0.02$). **Conclusion:** Therefore, mindfulness meditation mobile application can serve as another medium of delivery in addressing the problems of stress and anxiety. However, future research is warranted to determine the biological effects of mindfulness meditation.

Keywords: Anxiety, mindfulness meditation, mobile application, stress

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Introduction

Stress and anxiety are frequently seen as significant contributors to disease, and clinical evidence is mounting for specific negative effects of stress on immunological and cardiovascular-related diseases.^[1-4] Numerous psychological treatments are available to manage stress and anxiety. These can decrease people's suffering and enhance their quality of life.^[5-7] However, self-help programs may be effective in treating these problems as well. Meditation is considered one of the self-help tools that help cope with daily stress and anxiety. It is recommended by many clinical psychologists to reduce stress and anxiety level in people's daily life.^[8,9]

Many types of meditation have been discovered and practiced, some of which are concentration meditation, Om meditation, transcendental meditation, Zen meditation, loving-kindness meditation, mindfulness meditation, and others. In recent times,

mindfulness meditation is quite famous and practiced worldwide.^[10-14]

Mindfulness meditation techniques have emerged from the ancient meditative practices of the Buddhist tradition. It facilitates breathing, focused attention, and attention toward thoughts in a detached manner. Therefore, it exerts its effect on attention regulation, body awareness, nonjudgmental awareness of thoughts, emotional stability, and a change in the perception of self. Hence, it produces beneficial effects on well-being and reduces psychiatric and stress-related symptoms. Mindfulness meditation is, therefore, increasingly being incorporated into psychotherapeutic interventions.^[14]

In recent times, mindfulness meditation training is being delivered using mobile applications (apps). It is considered as a tool that can guide the practitioner through the meditation techniques effectively, something that is popularly called "guided mindfulness meditation."

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There is growing evidence of the positive impact of mindfulness on psychological stress, anxiety, depression, and attention deficit hyperactivity disorder.^[9,15-18] However, limited research has been done on the effectiveness of the mindfulness-based mobile apps on stress and anxiety.^[19-21] There are different health claims that have been made by some prominent mobile app developers, which are not based on any research supporting the use of their programs. Most of them use the existing general research on mindfulness to support the effectiveness of their apps without carrying any proper research. In presenting how their apps relate, most companies simply provide a link to a recent ongoing mindfulness study or a more extensive meta-analysis on mindfulness. Moreover, this in no way whatsoever gives a true picture of what their app is all about.

Hence, it was decided that it is important to determine the effectiveness of the mobile-based mindfulness meditation as a potential alternative delivery medium to address the issue of psychological stress and anxiety.

Aim

The aim was to determine the effectiveness of a mindfulness meditation mobile app in reducing perceived stress and anxiety.

Objectives

Two independent studies were conducted to determine the effectiveness of a mindfulness meditation mobile app in reducing perceived stress and anxiety.

1. A cross-sectional study was conducted to measure the perceived stress and anxiety between meditators (users who practiced mindfulness meditation for 90 days using the mobile app) and nonmeditators (new users who have not practiced any form of meditation)
2. A longitudinal study was conducted to measure the perceived stress and anxiety at the baseline and after

practicing mindfulness meditation for 21 days using the mindfulness meditation app.

Materials and Methods

Mobile app development

A mindfulness meditation app called “aware” was developed. It comprised the foundation program on mindfulness meditation techniques. The mindfulness techniques included in the foundation program are presented in Table 1. This program was designed as a guided session. Moreover, the content of the program was based on Kabat-Zinn mindfulness meditation program.^[22] An Android developer, an iOS developer, and a web designer constructed the mobile app for Android and iOS. The app was uploaded to the Google and Apple play stores.

Subject recruitment

Once the app was uploaded to the Google and Apple play stores, Facebook notifications were sent on the “aware mindfulness meditation” web page that was specifically created for the app. Participants all around the world participated in this research study by downloading the mobile app. The users that were interested in participating in the research study completed a questionnaire. Two thousand eight hundred and sixty-three users completed the questionnaire before starting the meditation practice. Two hundred and twenty-three users completed the questionnaire after completing 21 days of the foundation program. One hundred and eighteen users completed the questionnaire after completing 90 days of the foundation program.

Study group

Cross-sectional study

Users who remained active after 90 days of participation were shortlisted for the meditation group. As a result, 111 meditators were shortlisted for the study. Among 2863 newly enrolled users, 111 nonmeditators were shortlisted

Table 1: Mindfulness meditation techniques included in the 21-day foundation program

Days	Name of the techniques	Timings (min)
1	Simple breathing exercise, breath-focused attention, mindscape - letting go of the focus	10
2	Simple breathing exercise, breath-focused attention by breath-counting technique, mindscape - letting go of the focus	10
3	Simple breathing exercise, breath-focused attention by breath-counting technique, mindscape - letting go of the focus	10
4	Simple breathing exercise, breath-focused attention by breath-counting technique, soundscape-focused attention on the sounds, mindscape - letting go of the focus	10
5, 6, and 7	Simple breathing exercise, breath-focused attention by breath-counting technique, soundscape-focused attention on the sounds, bodyscape-focused attention on the body sensations, mindscape - letting go of the focus	10
8-14	Simple breathing exercise, breath-focused attention by breath-counting technique, soundscape-focused attention on the sounds, bodyscape-focused attention on the body sensations, mindscape - letting go of the focus	15
15-90	Simple breathing exercise, breath-focused attention by breath-counting technique, soundscape-focused attention on the sounds, bodyscape-focused attention on the body sensations, mindscape - letting go of the focus	20

using a simple random sampling technique performed using IBM SPSS Statistics for windows, Version 23.0. Armonk, NY: IBM Corp.

Longitudinal study

The users who had completed the questionnaire before and after 21 days of practicing mindfulness meditation alone were considered for this study. As a result, 67 users were shortlisted for the study.

In both the studies, users who practiced other relaxation techniques such as yoga, physical exercise, massage, visualization exercise, and other relaxation exercises were excluded from the study. Users who had not completed the questionnaire and who had taken the survey twice were excluded from the study. The users from the cross-sectional study and the longitudinal study did not overlap with each other.

Measurements

Independent variables

Depression Anxiety Stress Scales (DASS-21), a short version of the DASS, was used to assess psychological symptoms [Table 2]. The stress scale assesses the sensitivity levels of chronic nervous arousal, difficulties in relaxation, and feelings of being upset/agitated, irritability or over-reactivity, and impatience. The anxiety scale assesses autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect. The participants were asked to use a four-point rating scale (0 = did not apply to me at all, 1 = applied to me to some degree or some of the time, 2 = applied to me to a considerable degree or a good part of the time, and 3 = applied to me very much or most of the time). In the present study, only the stress and anxiety scale was measured by calculating the sum of scores for the relevant items pertinent to the stress and anxiety domain.^[23] Higher total scores represent higher levels of the measured factors.

Demographics

Regarding demographic characteristics, the user’s age, gender, and ethnicity were collected.

Ethical considerations

The Research Ethics Committee of Uber Health Tech Pvt. Ltd, Bengaluru, approved this study. All participants were assured that their personal data would be confidential and would not be disclosed at the time of publishing the research study.

Data collection

In this study, the app itself was used for data collection. The DASS and the demographic information were uploaded to the app so that when the users downloaded the app, they would fill the questionnaire if they were interested in participating in the research study.

Statistical analysis

In the cross-sectional study, a Chi-square test was used to compare between meditators and nonmeditators for demographic variables such as age, gender, and ethnicity. The Mann–Whitney U-test was performed to determine the differences between the group effects of perceived stress and anxiety. In the longitudinal study, a Wilcoxon signed-rank test was performed to determine the difference between the group effects of perceived stress and anxiety. $P < 0.05$ was considered statistically significant in all tests. Statistical analyses were performed using IBM SPSS Statistics 23.0 software.

Results

Cross-sectional study

Table 3 shows the demographic characteristics of the participants. To test whether the proportion of the demographic characteristics was different in each group, a Chi-square test with α equal to 0.05 as a criterion for significance was used. Statistically significant differences between meditators and nonmeditators were

Table 2: Depression Anxiety Stress Scale-21 subscale severity total scorings

Severity	Stress	Anxiety
Normal	0-14	0-7
Mild	15-18	8-9
Moderate	19-25	10-14
Severe	26-33	15-19
Extremely severe	34 and above	20 and above

Table 3: Cross-sectional study demographic characteristics of the participants (n=222)

	Meditation group (n=111), n (%)	Nonmeditation group (n=111), n (%)	P
Age			
18-25	21 (18.91)	28 (25.22)	0.58 ^a
26-35	39 (35.13)	42 (37.83)	
36-45	24 (21.62)	20 (18.01)	
46-55	15 (13.51)	14 (12.61)	
56-68	12 (10.83)	7 (6.33)	
Gender			
Male	73 (65.76)	52 (46.85)	<0.001 ^a
Female	38 (34.24)	59 (53.15)	
Ethnicity			
Caucasian	40 (36)	28 (25.22)	<0.001 ^a
European	54 (48.64)	41 (36.93)	
Asian	14 (12.61)	19 (17.12)	
African	0 (0)	2 (1.81)	
American			
Hispanic or Latino origin	3 (2.75)	9 (8.11)	
Australian	0 (0)	12 (10.81)	

^aChi-square test. Statistically significant standardized residual ($P < 0.05$)

found for gender $\chi (1, n = 222) = 8.07, P < 0.001$, and ethnicity $\chi (5, n = 222) = 21.65, P < 0.001$. No statistical significant differences were found between meditators and nonmeditators for age $\chi (4, n = 222) = 2.82, P = 0.58$.

A Mann–Whitney U-test was performed to determine the differences between the meditators and nonmeditators for the perceived stress and anxiety score. A statistically significant reduction in the perceived stress and anxiety scores for meditators compared to the nonmeditators was found [Table 4].

Longitudinal study

The longitudinal study allowed to additionally control demographic characteristics of participants, as the post and pretest scores describe the same individuals. Table 5 shows the demographic characteristics of the participants. A Wilcoxon signed-rank test was performed to determine whether there is a statistical difference between the pre- and posttest score for perceived stress and anxiety. The result indicated that the posttest ranks were lower than the pretest ranks for stress ($n = 67$, pretest mean rank = 30.89, posttest mean rank = 30.32, $Z = -2.41, P = 0.01$) and anxiety ($n = 67$, pretest mean rank = 33.55, posttest mean rank = 31.99, $Z = -2.41, P = 0.02$). Using the Mann–Whitney U-test, statistically significant differences for stress change score among Europeans ($n = 26$) compared to Caucasian ($n = 23$) ($n = 49$, European stress change score mean rank = 19.81 and Caucasian stress score change mean rank = 30.87, $Z = -2.70, P = 0.05$) were found. There were also statistically significant differences for anxiety change score among Europeans ($n = 26$) compared to Caucasian ($n = 23$) ($n = 49$, European stress change score mean rank = 19.90 and White American stress change score mean rank = 30.76, $Z = -2.66, P = 0.05$).

Discussion

This is the first study where the effectiveness of a mindfulness meditation app was studied by considering the users of the app. The objective of this study was to determine the efficiency of using a mindfulness meditation app in reducing stress and anxiety. Two independent studies were conducted: one was a cross-sectional study and the other one was a longitudinal study.

In the cross-sectional study, there was a statistically significant decrease in perceived stress and anxiety in meditators compared to nonmeditators. In the longitudinal study, there was a statistically significant difference in the stress and anxiety change score. Moreover, a statistically significant difference was found in Europeans compared to Caucasian in relation to their stress and anxiety change score. This shows that there are disparities in the level at which Europeans and Caucasian experience stress and anxiety. Psychological stress and anxiety are common problems that constitute a large socioeconomic burden, and self-help programs delivered by an app would provide an easy way to offer treatment in the day-to-day life. Despite increasing numbers of mindfulness apps, very few of them have been tested for effectiveness.^[19-21] The effectiveness of a mindfulness meditation app for perceived stress and anxiety was determined.

As predicted, in both the cross-sectional and the longitudinal studies, a significant reduction in the stress score, as measured by the stress scale from the DASS, was established. This supports existing research findings that mindfulness meditation can have positive psychological effects on people exposed to stress.^[24,25]

The explanation for the disparities related to stress may be found in allostatic load^[26] as well as the weathering framework^[27] theories. The first theory, allostatic load, places emphasis on the effect of cumulative risks that result from inveterate exposure to the challenges of life as well as stress-impairing allostasis (the ability of the body to conserve homeostasis).^[26] Placing an excessively high demand on the regulatory systems affects the activity of the autonomic, the metabolic, the neuroendocrine, and the cardiovascular systems, which brings about a state of illness, for example, diabetes.^[28] In any situation where there is a limited or overused potential adaptive and protective stress response, either behavioral or physiological, it results in an impaired health as well as an allostatic overload.^[26]

Stress responses can be overused when the mind indulges in a constant flow of thoughts either about the future or the past. Individuals tend to become overwhelmed with thoughts, and this constant flow of thoughts may cause a chemical imbalance, like an increased level of cortisol which, in term, affects the physiology of the body.^[29]

To bring about a reduction in the health disparities that are related to stress, there must be a program to which

Table 4: Cross-sectional study: Mann-Whitney U-test score of stress and anxiety

Group	n	Mean	Median	Standard deviation	Mean rank	U	P
Self-report stress score							
Meditation group	111	10.85	10.00	7.18	94.22	4242	<0.000
Nonmeditation group	111	15.15	14.00	8.18	128.78		
Self-report anxiety score							
Meditation group	111	10.07	9.00	7.70	95.21	4352.50	<0.000
Nonmeditation group	111	14.38	12.00	8.76	128.78		

Statistically significant standardized residual ($P < 0.05$)

Table 5: Longitudinal study demographic characteristics of the participants (n=67)

	n (%)
Age	
18-25	14 (20.89)
26-35	26 (38.80)
36-45	13 (19.41)
46-55	8 (11.95)
56-68	6 (8.95)
Gender	
Male	44 (65.67)
Female	23 (34.33)
Ethnicity	
White American	23 (34.32)
European	26 (38.80)
Asian	6 (8.95)
African American	1 (1.50)
Hispanic or Latino origin	2 (2.99)
Australian	2 (2.99)
Asian American	1 (1.50)
Others	6 (8.95)

everyone can have easy access to. For over 10 years now, many research studies to check for the advantages of both complementary and alternative approaches to medicine in attaining reduction of the effects and the money spent on inveterate health conditions have been funded by the National Center for Complementary and Alternative Medicine.^[30] Meditation is one important intervention in the management of stress that was reported in research studies. From the data obtained from the National Institutes of Health, the main aim of carrying out a study in this area is for the purpose of examining the ways in which meditation and other interventions for the mind and the body can “enhance resilience, positive affect, and coping to improve health and well-being and prevent or slow disease progression.”^[30]

One form of meditation, mindfulness, enhances the self-regulation of attention to be more focused on the present-moment experience and to let go of the cognitive fixation on past or future events.^[15,31] Many research studies have shown that mindfulness meditation helps reduce negative reactions to stress and improve reactions to depression and overall well-being.^[32-36]

In a famous Dow Chemical Company study, employees who practiced mindfulness-based stress reduction program for 7 weeks showed a reduction in perceived stress. Company-based mindfulness meditation programs, however, are relatively novel. As a result, few studies have been conducted to assess their effectiveness. One such study, administered to employees of Dow Chemical Company, noted increases in workplace satisfaction and decreases in stress, as well as improvements in resilience, vigor, and mindfulness (measured by the Five-Facet Mindfulness Questionnaire) compared to the wait-list

control group.^[33] Therefore, mindfulness meditation reduces multiple negative dimensions of psychological stress.

In both the cross-sectional and the longitudinal studies, there was a statistically significant reduction in the anxiety score. These research findings were supported by other research studies. In a recent study, to examine the effects of a short-term web-based mindfulness program, participants who self-described as stressed were recruited, and there was a random placement of 70 participants in a treatment group ($n = 35$) and a control group ($n = 35$). A mindfulness program was conducted in two ways, including 10 min of exercises in each day, for 6 days in the space of a week for 2 weeks. The training was completed by only 34 participants in the control group and 20 participants in the treatment group. Measures of anxiety, stress, symptoms of depression, as well as a questionnaire on mindfulness meditation were administered before the beginning of the treatment, after 1 week of treatment, and at the end (2 weeks) of the treatment. From the results, it was discovered that there was an increment in mindfulness skills as well as a reduction in the levels of perceived anxiety, stress, and symptoms of depression as a result of mindfulness training.^[34]

Anxiety is a cognitive state connected to an inability to regulate the emotional responses to perceived threats. Practicing mindfulness meditation strengthens a person’s cognitive ability to regulate emotions such as anxiety. For example, while practicing mindfulness meditation, thoughts that may bring worry will be viewed as thoughts, rather than the reality of the situation. The shift from a judgmental thought process to a nonjudgmental awareness might bring down the anxiety level and help users handle anxiety-provoking situations.

From the longitudinal study carried out, it was observed that there was a substantial reduction in the level of stress and anxiety for Europeans when compared to Caucasian. This submission is the first research study to work on determining how effective is the use of mindfulness meditation in populations in Europe over the ones in America, focusing on Caucasian participants.

Limitations

The major limitation in the cross-sectional study was finding the significant differences in gender and ethnicity among meditators and nonmeditators. As a result of the fact that the data did not follow a normal distribution, it was impossible to determine the disparities in stress and anxiety for meditators and nonmeditators after variables such as ethnicity and gender had been controlled for. Nevertheless, for the longitudinal study, an extra control was used for the demographic characteristics making it possible to see that the reduction in the level of stress and anxiety as a result of practicing of mindfulness meditation was independent.

The major limitation to the longitudinal study was that there was no recruitment of a comparable control group.

This led to the reduction in the ability of the researchers to link the substantive changes to the mindfulness meditation with some level of certainty. It also reduced the power to reaching clear conclusions regarding the nature of the effects of the mindfulness meditation. Nevertheless, there are two aspects of the research that supports the experimental hypothesis, which suggest that the lack of a control group was not a problem in a situation like this. The first aspect is associated with the fact that the effects that were seen were founded on research that has already been conducted before and which are reasonably strong. The results were associated with the predicted direction. The second aspect is that there would have been some substantive results that opposed the expected direction if some of the observed effects were based on chance. Therefore, based on the fact that all the effects that were observed were all in the predicted direction, the results suggest an in-depth design.

It is suggested, therefore, that these results are taken as preliminary results and that a study that is completely randomized is done to verify them, as this will compensate for the potential deficiency associated with the lack of an effective control group.

Since majority of the participants were Caucasian and Europeans, the findings cannot be generalized. Hence, further randomized studies involving participants from different ethnicities and from different geographical areas should be conducted to generalize the findings of the present study to the world population. Furthermore, the present study involved only the healthy participants. To extend the findings of the present study to the patient population, randomized studies should be conducted in patients with different levels of anxiety and depression. Biochemical markers of physiological stress and anxiety such as endorphins, cortisol, and oxidative stress markers should also be evaluated along with the anxiety and depression scores to further validate the role of the intervention in reducing stress and anxiety.

Conclusion

The time commitment and the cost of participating in a mindfulness meditation program in person can be significant. However, learning and practicing mindfulness meditation using a mobile app can be easy, cost-effective, and associated with significant positive effects that are similar to those when learning mindfulness in the presence of a teacher.

It was found that the effect of mindfulness meditation on perceived stress and anxiety was consistent with expectations. The result of the perceived stress and anxiety measures suggests that mindfulness meditation had a pronounced positive psychological effect on the users. Future research is warranted to determine the biological effects of mindfulness meditation.

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Conflicts of interest

There are no conflicts of interest.

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