Does a Meditation Protocol Supported by a Mobile Application Help People Reduce Stress? Suggestions from a Controlled Pragmatic Trial

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Abstract

The aim of this study was to examine the efficacy of a 3 week mindfulness inspired protocol, delivered by an Android application for smartphones, in reducing stress in the adult population. By using a controlled pragmatic trial, a self-help intervention group of meditators was compared with a typical control group listening to relaxing music and a waiting list group. The final sample included 56 Italian workers as participants, block randomized to the three conditions. The self-reported level of perceived stress was assessed at the beginning and at the end of the protocol. Participants were also instructed to track their heart rate before and after each session. The results did not show any significant differences between groups, but both self-help intervention groups demonstrated an improvement in coping with stress. Nevertheless, meditators and music listeners reported a significant decrease in average heartbeats per minute after each session. Furthermore, both groups perceived a moderate but significant change in stress reduction perceptions, even if with some peculiarities. Limitations and opportunities related to the meditation protocol supported by the mobile application to reduce stress are discussed.

Introduction

Stress is a growing problem nowadays, affecting many people and significantly worsening quality of life.1 If it is not possible to eliminate stress completely, it is important to learn how to deal with it.

Self-help programs, such as interventions that people practice individually without contact with a professional in the field, have been demonstrated to be effective in helping people practice stress management techniques and in reducing anxiety and stress symptoms.2–7 The effectiveness of self-help programs, together with the growing need to find innovative and effective interventions in healthcare services to cope with stress, has led to the creation of brief protocols supported by interactive media. Self-help interventions supported by technologies enable individuals to overcome some limits related to traditional support, such as time, resources, flexibility, accessibility, and availability.8 According to the European Commission’s Green Paper on mobile Health,9 mobile health covers medical and public health practice supported by mobile devices, such as mobile phones. It also includes applications (“apps”) such as lifestyle and well-being apps primarily intended to maintain or improve healthy behaviors, quality of life, and the well-being of individuals directly or indirectly.

In recent years, many mobile apps for mental health have been developed and have demonstrated potential for stress and anxiety management.10–12 The approaches to coping with stress typically used in self-help mobile interventions include (a) relaxation training, such as Autogenic Training,13 Progressive Muscular Relaxation,14 and breathing techniques; (b) music15,16; and (c) cyber interventions based on Stress Inoculation Training methodology (cyber-SIT), which utilize advanced technologies to create simulations to teach individuals how to cope effectively with psychological stress.17

Another emerging approach is based on mindfulness meditation.18 Mindfulness meditation can be described as a process of bringing a certain quality of attention to moment-by-moment experience.19 In contemporary psychology, it has been adopted as an approach to increase awareness and respond skillfully to mental processes that contribute to emotional distress and maladaptive behavior.20

Several interventions using the traditional Mindfulness-Based Stress Reduction protocol demonstrated good results in reducing levels of stress, anxiety, and depression in both

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the clinical and the nonclinical population,21–26 but these programs are time intensive, requiring both in- and out-of-session practice, and sometimes are difficult for people with minimal experience with meditation. The consequence of this commitment could cause barriers to its widespread application.27

To overcome these limits, brief mindfulness meditation protocols have been realized and their efficacy confirmed for nonclinical populations also at risk for stress-related health problems.28,29 Nevertheless, only a few studies have integrated them in self-help interventions supported by new technologies and mobile apps.30–35 Furthermore, the effectiveness of self-help apps aimed to help people in practicing mindfulness techniques (such as Mindfulapps and Mind-Apps, both released from iTunes in 2012) has not been formally studied yet. Recently, a mobile app focused on a specific technique—thought distancing (i.e., a mindfulness technique that requires a person not to react in response to one’s own thoughts but to be aware of them and observe them while they go away), which aims to enable decentering—has been formally evaluated and good results have been obtained in terms of achieved mindfulness, perceived level of difficulty, and degree of pleasantness.34

Starting from these premises, the aim of this study was to test the effectiveness of a brief self-help protocol inspired by mindfulness meditation and delivered through a smartphone app in reducing stress for the nonclinical population. Specifically, sitting meditation was the focus, consisting of different exercises, such as mindful breathing and thought distancing. In terms of mindful breathing, participants learned how to direct their attention to the sensations of breathing and to notice when their mind wandered away24; in terms of thought distancing, participants had to try to perceive thoughts as “events” in their minds, simply observing the process of thought.

To reach this aim, a controlled pragmatic trial was used. These trials are typically designed to test the effectiveness of interventions in real life in order to maximize their applicability and generalizability.36 This intervention was compared with a common approach used by individuals in real-life conditions, such as a brief relaxation protocol based on passive listening to relaxing music37 (control group). A waiting list group with no treatment was also included, which served as an untreated comparison group during the study.

In particular, the study evaluated whether:

**H1:** A significant difference in decreased stress existed among the three groups.

**H2:** A significant reduction in perceived stress existed within the intervention groups (meditators and music listeners).

Furthermore, as mobile Health is an emerging field, which has the potential to play a part in the transformation of healthcare, the study attempted to understand whether participants were in favor of trying meditation experiences through mobile devices.

**Methods**

**Participants**

One hundred flyers were posted on the bulletin board of some companies and associations in Milan to attract participants. The recruitment criteria were as follows: (a) >18 years old, (b) employed, and (c) a native Italian speaker. People who responded received an e-mail containing more information about the research and an invitation to the first meeting. Fifty-six participants (32 women) were recruited with an age range of 20–52 years ($M = 38.11$, $SD = 6.92$).

With regard to education level, 32.1% had a high school diploma, 66.1% a degree, and 1.8% other qualifications. White-collar workers comprised 66.1% of the sample, consultants 7.1%, salespeople 17.9%, entrepreneurs 3.6%, with the remaining 5.3% having other occupations. Participants took part voluntarily in the intervention after signing the informed consent form. They were randomly assigned to the self-help intervention group (meditation; 20), the control group (music; 18), or the waiting list group (18).

**Application**

The app “It’s time to relax!” was created by using the Eclipse Integrated Development Environment (IDE). The implementation was tested on a Samsung Galaxy Y terminal, kindly loaned by Samsung Italia, equipped with Android v2.2. Figure 1 shows two examples of the app: on the left a breath meditation and on the right the homepage layout.

**Measures**

To verify the changes in perceived stress level, the Italian validated version of the Mesure du Stress Psychologique (MSP) questionnaire was used,38,39 which evaluates one’s perceived stress level within the preceding 3 months. The Cronbach’s alpha of the Italian validated version is 0.95. It includes 49 items and considers six dimensions: (a) loss of control and irritability, (b) psychophysiological feelings, (c) sense of effort and confusion, (d) depressive anxiety, (e) pain and physical problems, and (f) hyperactivity and accelerated behaviors. The MSP was administered before and 3 weeks after the interventions.

**FIG. 1.** Layout of the “It’s time to relax!” application.
In addition, this study looked at identifying the affective state of the participants by using a psychophysiological measure, such as heart rate (HR). Long-term meditation practice has been shown to reduce HR. The hypothesized mechanism by which meditation has this effect is by inducing a feeling of relaxation, which decreases physiological arousal.\(^{40–42}\) Specifically, participants were asked to track their beats per minute (BPM) before and after each session and to include the data on the daily activities form.\(^{43}\) The rationale is easy to understand: the higher the relaxation experienced through meditation is, the higher the possibility will be of observing a modification in physiological indexes in terms of BPM reduction.

To verify both the level of difficulty and the usefulness of the self-help interventions delivered by a mobile app, two items rated on a 5-point Likert scale were used. Questions related to difficulty were “How did you find the tasks required by the testing?” and “How did you find the detection of heartbeats?” (1 = “very difficult”, 5 = “very easy”). Questions related to usefulness were “Did you find the trial useful?” and “Would you suggest this type of practice for stress management?” (1 = “strongly disagree”, 5 = “strongly agree”). To obtain a composite measure, the sum of the two items was averaged for a single mean score.

**Procedure and protocol**

All participants were initially met and given instructions and descriptions of the research. Baseline psychometric assessment and demographic data were collected (time 0). The protocol for the two self-help intervention groups was as follows (Fig. 2). Meditation participants had to practice two mindfulness meditations per day, lasting 15 minutes each, by listening to the guided or free (starting from the second week) meditation supported by the smartphone application “It’s time to relax!” Music listeners had to use their mobile device to listen to two pieces of relaxing music (chosen from a proposed list) per day, lasting about 15 minutes each, while doing nothing else.

Specifically, the following guided meditations were proposed. Brief meditation was translated from the Three-Minute Breathing Space Meditation.\(^{44}\) This is a short meditation, designed to be inserted into a busy and full life. In a few minutes, the participant can become aware of his thoughts and physical sensations and remain in contact with the present thanks to the breath. Mindful Breathing was adapted from Breathing Meditation.\(^{45}\) The participant is invited to sit in a calm and peaceful location, and focus his/her attention on his/her breath and bodily movement (chest, belly). When his/her mind wanders, the participant is invited to notice that he/she has distracted and return to observe breathing. Mountain meditation is adapted from Jon Kabat-Zinn script\(^{46}\) and aims to experience thoughts and feelings as events passing through the mind, rather than as facts. This practice asks the participant to focus his/her attention on a specific object—in this case a mountain—and to notice the thoughts, sensations, and emotions that appear in mind and let them go (acceptance, self-compassion, thought distancing). The participant is invited to sit quietly in a comfortable location where he/she can devote full attention to imagine a beautiful mountain. He/she can observe the mountain that remains solid, firm, and steadfast in front of all the changes that take place around and on him/her. Snow, storms, heat, cold, seasons—everything changes, but the mountain remains firm and solid observing all these changes. The participant can become like a mountain, accepting changes in his/her life, remaining as solid and strong as the mountain.

As suggested by pragmatic trials,\(^{36}\) participants were not constrained by guidelines on how to apply the experimental intervention: they could freely choose the time for the relaxation sessions, with the only rule being to avoid any other activity during the sessions. Moreover, no special strategy was used to motivate participants’ adherence to the trial protocol. Both groups were asked to specify the meditation selected among the options, to track their BPM before and after each session, and to include the data on the daily activities form. Specifically, for the BPM detection, the following instructions were provided: “Before and after every session, please monitor your carotid heart rate, putting the first (index) and middle finger on the side of your neck in the soft hollow area just beside your wind-pipe, then count the number of beats you feel for one full minute” (music listeners); or “Count the number for 10 seconds and then click on the heart” (meditation participants, because the app automatically multiplied the number by six).

To ensure that participants made the BPM measure correctly, a short training session was conducted. The training was aimed at verifying the right position of the fingers for the beats detection and the correct number of counted beats. For this reason, participants were asked to measure the beats five times both manually and by using a pulse oximeter, that is, a reliable noninvasive tool commonly used by nonprofessional end users. A 95% confidence rate was found with a margin of error of ±4%, which could be considered acceptable.\(^{47}\)

![FIG. 2. Protocol diagram.](image-url)
Attrition rate and protocol adherence

As far as the attrition rate is concerned, of the 56 participants randomized in this study, 100% completed the questionnaire before and after intervention. By analyzing the daily activities form, 55.3% of participants were found to have followed the instructions and completely filled out the activity form twice a day (specifically, 40% of meditators and 72.2% of the music group participants); 26.3% carried out at least one activity per day (45% performed at least one meditation, and 5.6% listened to at least one song); and 18.4% showed no regularity of execution and then jumped a few days of exercises and relative measurement of the beats (15% of meditators and 22.2% of the music group participants).

Furthermore, the daily activities form that records whether participants performed only the guided meditations (breath and mountain) in the first week, as required in the instructions, was checked. In general, the participants followed the guided sessions at least 50% of the time as they performed the meditation exercises. The remaining sessions were followed in a uniform manner among the free and brief sessions.

Data analysis

First, the stress levels were compared among the three groups at the baseline, and no significant differences were found, as measured by the MSP questionnaire.

This study measured the difference in decreased stress, both with self-report and BPM monitoring, among groups. Due to the low number of participants included in each group and to overcome the low statistical observed power, gain score variables were created with the difference between values of the original variable of stress at the two times of the protocol (end and beginning) and with the average daily BPM assessed before and after each of the two sessions. These variables were used to conduct the analysis.

Results

Following Dimitrov and Rumrill, a one-way analysis of variance was used on gain scores to compare the measurement of stress change perceptions among groups (H1). No significant differences were found between the groups in the items measured on the MSP questionnaire (Table 1). No differences were even found between meditation participants and music listeners as far as the BPM monitoring is concerned (Table 2). However, it is important to stress that the waiting list group showed a constant increase in all MSP dimensions.

In addition, this study evaluated the effect achieved by meditation in the self-help intervention group and by listening to music in the control group in terms of perceived stress reduction (within-groups effect; H2). Both the meditation and music groups reported a stress reduction, as measured by self-report, but with some peculiarities for each group. In particular, participants who practiced meditation reported a reduction in hyperactivity and accelerated behaviors (\( p = 0.010, T = 2.874, df = 19; T_0; M = 7.25, \))

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**Table 1. Analysis of Variance Measurement of Stress Change Perceptions Among Groups**

<table>
<thead>
<tr>
<th>Gain score dimensions</th>
<th>Group</th>
<th>M</th>
<th>SD</th>
<th>df</th>
<th>F</th>
<th>p</th>
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<tbody>
<tr>
<td>Hyperactivity and accelerated behaviors</td>
<td>Meditation</td>
<td>-1.00</td>
<td>1.56</td>
<td>2</td>
<td>1.739</td>
<td>0.185</td>
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<tr>
<td></td>
<td>Music</td>
<td>-0.56</td>
<td>1.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waiting list</td>
<td>0.06</td>
<td>1.92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of control and irritability</td>
<td>Meditation</td>
<td>-0.15</td>
<td>3.03</td>
<td>2</td>
<td>0.984</td>
<td>0.381</td>
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<tr>
<td></td>
<td>Music</td>
<td>-0.44</td>
<td>2.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waiting list</td>
<td>0.67</td>
<td>2.03</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Psychophysiological feelings</td>
<td>Meditation</td>
<td>-0.30</td>
<td>2.41</td>
<td>2</td>
<td>0.556</td>
<td>0.577</td>
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<tr>
<td></td>
<td>Music</td>
<td>-0.17</td>
<td>1.46</td>
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<td></td>
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<td></td>
<td>Waiting list</td>
<td>0.28</td>
<td>0.96</td>
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<tr>
<td>Sense of effort and confusion</td>
<td>Meditation</td>
<td>0.15</td>
<td>2.27</td>
<td>2</td>
<td>1.629</td>
<td>0.206</td>
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<tr>
<td></td>
<td>Music</td>
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<td>1.25</td>
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<tr>
<td></td>
<td>Waiting list</td>
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<td>1.89</td>
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<td></td>
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<tr>
<td>Depressive anxiety</td>
<td>Meditation</td>
<td>0.15</td>
<td>2.60</td>
<td>2</td>
<td>0.05</td>
<td>0.952</td>
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<tr>
<td></td>
<td>Music</td>
<td>0.22</td>
<td>1.93</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Waiting list</td>
<td>0.00</td>
<td>1.81</td>
<td></td>
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<td></td>
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<tr>
<td>Pain and physical problems</td>
<td>Meditation</td>
<td>-0.05</td>
<td>2.53</td>
<td>2</td>
<td>2.372</td>
<td>0.103</td>
</tr>
<tr>
<td></td>
<td>Music</td>
<td>-1.06</td>
<td>1.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waiting list</td>
<td>0.33</td>
<td>1.33</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Beats Per Minute (BPM) Changes Between Groups (Meditation and Music)**

<table>
<thead>
<tr>
<th>Session</th>
<th>F</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 1</td>
<td>0.664</td>
<td>1</td>
<td>0.422</td>
</tr>
<tr>
<td>Session 2</td>
<td>0.171</td>
<td>1</td>
<td>0.202</td>
</tr>
<tr>
<td>Session 3</td>
<td>0.270</td>
<td>1</td>
<td>0.608</td>
</tr>
<tr>
<td>Session 4</td>
<td>0.190</td>
<td>1</td>
<td>0.179</td>
</tr>
<tr>
<td>Session 5</td>
<td>0.187</td>
<td>1</td>
<td>0.699</td>
</tr>
<tr>
<td>Session 6</td>
<td>0.376</td>
<td>1</td>
<td>0.062</td>
</tr>
<tr>
<td>Session 7</td>
<td>0.182</td>
<td>1</td>
<td>0.187</td>
</tr>
<tr>
<td>Session 8</td>
<td>0.183</td>
<td>1</td>
<td>0.186</td>
</tr>
<tr>
<td>Session 9</td>
<td>0.759</td>
<td>1</td>
<td>0.391</td>
</tr>
<tr>
<td>Session 10</td>
<td>0.160</td>
<td>1</td>
<td>0.215</td>
</tr>
<tr>
<td>Session 11</td>
<td>0.225</td>
<td>1</td>
<td>0.639</td>
</tr>
<tr>
<td>Session 12</td>
<td>0.259</td>
<td>1</td>
<td>0.118</td>
</tr>
<tr>
<td>Session 13</td>
<td>0.119</td>
<td>1</td>
<td>0.733</td>
</tr>
<tr>
<td>Session 14</td>
<td>0.711</td>
<td>1</td>
<td>0.406</td>
</tr>
<tr>
<td>Session 15</td>
<td>0.102</td>
<td>1</td>
<td>0.319</td>
</tr>
<tr>
<td>Session 16</td>
<td>0.104</td>
<td>1</td>
<td>0.316</td>
</tr>
<tr>
<td>Session 17</td>
<td>0.410</td>
<td>1</td>
<td>0.527</td>
</tr>
<tr>
<td>Session 18</td>
<td>0.758</td>
<td>1</td>
<td>0.391</td>
</tr>
</tbody>
</table>


As far as the behavioral effect of stress reduction is concerned, the data show a significant decrease in the average BPM in both the meditation and the music groups, which is consistent with the relaxation response measured before and after each session (Table 4).

Participants’ answers about difficulty and usefulness were used to better understand their evaluation about the intervention. Both groups have evaluated the interventions as simple (meditation: $M = 2.43$; music: $M = 2.08$) and useful (meditation: $M = 3.65$; music: $M = 3.61$).

**Discussion and Conclusion**

More and more people are looking for self-help programs to enhance their well-being and health, which is consistent with the rapid growth of smartphone apps in behavioral healthcare. Interventions using real-time mobile technology have previously demonstrated efficacy to improve health outcomes in several domains, including anxiety and stress management. Mobile apps can encourage adherence to a healthy lifestyle, resulting in more personalized treatments. To date, research on both the design and potential uses of mindfulness-based mobile apps (MBMAs) is scarce. According to Plaza et al., while a wide selection of MBMAs seems to be available in the market, there is a complete lack of evidence to support the usefulness of those apps on health indicators.

This study aimed to test the effectiveness of a brief self-help intervention inspired by mindfulness meditation and was supported by a smartphone app in real life routine practice conditions, as suggested by the pragmatic trial approach.

Both thought distancing and mindful breathing exercises were included, and this intervention was compared with a typical brief relaxation protocol based on passive listening to relaxing music and a waiting list group.

Participants who completed the trial (85% of the meditators and 77.8% of the music listeners performed at least one exercise per day) favored both self-help intervention and music. Nevertheless, data did not confirm the first hypothesis. Despite the absence of statistically significant differences, as measured by self-report and BPM monitoring, it is important to note that the trend was different, and the waiting
list group experienced an increase in perceived stress, especially in terms of loss of control and irritability and sense of effort and confusion. Participants of this study were workers exposed to job stress, and the absence of treatment may have led to a worsening of their perceived stress. This result led us to believe that the duration of the meditation intervention was too short. An initial time is likely needed to learn meditation skills; after 3 weeks, the effects achieved were similar between groups. A longer intervention could overcome the initial difficulties and generate higher results in terms of acceptance and efficacy, as in the case of Ly et al.’s study, which found good results by using an 8 week smartphone-based mindfulness intervention with minimal therapist contact. As an alternative, it is suggested that interventions that require time to learn and practice specific skills might benefit from communication with a trainer or coach—face-to-face or from a distance—to introduce the approach.

As far as the second hypothesis is concerned, data confirmed the effectiveness of both interventions on stress reduction. Specifically, meditation participants reported a reduction in hyperactivity and accelerated behaviors, which is consistent with meditation practice. Mindfulness is a type of meditative technique that emphasizes an observant and nonreactive stance toward one’s thoughts, emotions, and body states. It involves purposeful attention to daily activities (e.g., mindfulness of eating). According to Zeidan et al., a brief mindfulness meditation intervention can be effective in reducing tension, fatigue, confusion, anxiety, and HR. Furthermore, several studies documented that mindfulness meditation often induces a state of relaxation, even if that is not an objective.

Participants who listened to music reported a reduction in pain and physical problems; this result is also consistent with a recent review showing that music interventions have positive effects on reducing patients’ anxiety and pain.

Although it was recorded just as self-monitoring, participants reported that by measuring the beats before and after each session, they became aware of the change of their physiological state as a result of the practice.

Both music and meditation were perceived as demanding, and participants felt that they had learned useful strategies. Nevertheless, many participants declared that it was not easy to make time to do the exercises, even though the self-help intervention helped them recognize the importance of self-regulating attention on their daily activities and finding personal space to relax. These perceptions confirm that mobile well-being apps represent a promising approach to encourage adherence to a healthy lifestyle anywhere and at any time, and to contribute to the empowerment of people to manage their health more actively, as announced in the eHealth Action Plan 2012–2020. For this reason, it is critical to analyze the potential outcomes of traditional protocol delivered by new technologies. This scientific scrutiny allows for understanding whether mindful-based self-help mobile apps can be beneficial to users in achieving mindfulness or pursuing learning of mindfulness. In this case, the practice has been pleasant and effective, but similar effects were found with the music intervention. Two critical aspects should be considered. One is the intervention duration: participants practicing meditation would need more than 3 weeks to become confident with the meditation approach. The second is subjective preference, according to which the effects of music on stress and anxiety reduction depend on personal preference, and this issue is also valid for meditation according to participants’ preference and abilities.

This is the first study in the field showing that an app can simplify the mindfulness approach making it usable in daily life. Nevertheless, there are some limitations. The small sample size and the short duration of the intervention lead us to consider the obtained results with caution. Further controlled pragmatic trials, also including psychophysiological sensors integrated within applications, are needed in order to verify the efficacy of meditation mobile protocols with competing methods, as well as to test the long-term effects achievable by the proposed approach.

**Author Disclosure Statement**

No competing financial interests exist.

**References**


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