

**Title:** Effects of mobile mindfulness on emergency department work stress: a randomised controlled trial

## **Abstract**

**Background:** High occupational stress among emergency department (ED) staff has a detrimental impact on both staff wellness and patient care.

**Objective:** To determine whether 4-weeks of smartphone app-guided mindfulness practice reduces stress-levels of ED staff.

**Method:** This two-arm randomised controlled trial was conducted in two Australian EDs in 2019-2020. Eligible participants were randomly assigned (1:1) to either an App group or a Wait to Treat group to practice daily 10 minutes app-guided mindfulness for 4 weeks. Online surveys were collected for both groups at three time periods: before (T1), immediately after (T2) and 3 months after cessation (T3). Then the Wait-to-treat group received the same intervention, followed by surveys immediately after the intervention (T4) and 3 months later (T5). Primary outcomes were measured using the Perceived Stress Scale. Secondary outcomes were measured using the Maslach Burnout Inventory (3 subscales: emotional exhaustion (EE), depersonalisation (DP) and personal accomplishment (PA)), Mindfulness Attention Awareness Scale and Warwick-Edinburgh Mental Well-being Scale. Both intention to treat (ITT) and per-protocol analysis were performed. Repeated measurement data were analysed by the linear mixed model.

**Results:** Of 148 enrolled participants 98 completed all the surveys, but only half (48%) reported continuous use of the app. Based on the results of the ITT analysis, there was a statistically significant improvement of perceived stress levels ( $F=15.70$ ,  $p<0.001$ ), all three components of burnout (EE ( $F=14.22$ ,  $p<0.001$ ), DP ( $F=3.62$ ,  $p=0.030$ ), PA ( $F=7.51$ ,  $p<0.001$ )), mindfulness ( $F=8.83$ ,  $p<0.001$ ) and wellbeing levels ( $F=10.71$ ,  $p<0.001$ ) from pre-intervention to 3 months later with small effect sizes.

**Conclusion:** Results of this study demonstrate that brief mindfulness training via innovative digital technology had a small positive effect in improving emergency staff stress, burnout, mindfulness and wellbeing.

**Keywords:** emergency care, mindfulness, occupational stress, randomised controlled trial, smartphone app

## **Key findings**

- Regular practice of smartphone-guided mindfulness between 2 and 10 minutes for 4 weeks can reduce stress and burnout as well as promote mindfulness and wellbeing among ED staff.
- Short but frequent mindfulness practice was preferred by participants.

## **INTRODUCTION (2497)**

The emergency department (ED) presents one of the riskiest environments for burnout<sup>1</sup> because of its unique challenges such as a consistently changing working environment and demanding rapid decision making in life-and-death situations. Other challenges include overcrowding, heavy workload, staff skill mix issues and workplace violence.<sup>2</sup> One in two ED doctors and nurses report burnout.<sup>1, 3</sup> Working in such an environment can lead not only to burnout with subsequent impacts on staff retention, productivity and patient care,<sup>4</sup> but also affect the physical, mental and psychological wellbeing of an individual. Although addressing root organisational causes is preferential<sup>5, 6</sup> this is often constrained by larger influences such as budgets. In comparison, addressing the effects by implementing smaller-scale wellness interventions such as mindfulness are more likely to alleviate stress and promote better staff wellbeing within a shorter time frame.<sup>7</sup> Mindfulness has proved to be effective in stress reduction for both the general population<sup>8</sup> and healthcare workers.<sup>9</sup> However, little evidence about mindfulness and its effect on ED staff stress is available.

Mindfulness is a form of training that focuses on bringing attention to the present moment non-judgmentally,<sup>10</sup> allowing an individual to be less reactive in stressful situations. Mindfulness training is often delivered face-to-face and it has been tested in the ED environment.<sup>11, 12</sup> However face-to-face group mindfulness training can be challenging to coordinate for ED shift workers who work different shifts. To overcome time constraints, alternative forms of delivery are required.

Despite mindfulness interventions delivered via online or digital platforms<sup>13</sup> suffering from drop out (20-30% attrition rate)<sup>14, 15</sup> they offer benefits of easier access, cost-effectiveness and increased the reach of service.<sup>16</sup> Mindfulness apps capitalise on these benefits, hence becoming ideal for workers who are unable to attend face-to-face sessions. Mindfulness apps have been used successfully in the highly stressful hospital environments of palliative and paediatric wards.<sup>17, 18</sup> However, the apps' effectiveness among ED staff is unclear.

This study aimed to test the effectiveness of a smartphone-guided mindfulness intervention in reducing stress and burnout among ED staff.

## **METHODS**

### **Trial design**

A ~~multi-site~~, prospective, two-arm RCT was conducted between August 2019 and July 2020. The study design followed the Consolidated Standards of Reporting Trials (CONSORT) guideline for RCTs.<sup>19</sup> The trial was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12619001175167) and was approved by the hospital and university ethics committees.

Eligible participants were randomised into either an 'App' group or the 'Wait to treat' group (abbreviated as Wait group) after an initial survey (T1) (Figure 1). App group members were requested to use the app for 4 weeks and complete the same survey both at the end of the intervention period (T2) and 3 months later (T3). The Wait group completed the surveys at the same times as the App group. Thereafter the Wait group became the experimental group. They were given access to the app and instructed to practice mindfulness for 4 weeks. Participants in the Wait group did two additional surveys at the end of the intervention period (T4) and three months later (T5). Those last two time points were then equivalent to the T2 and T3 time points of the initial App group.

### **Setting, participants and recruitment**

The study was conducted at two EDs in Queensland, Australia. All permanent or casual clinical and nonclinical staff having daily access to a smartphone with internet access were invited into the study. Screening excluded agency and external staff and those having practised meditation or yoga regularly in the past three months. A range of activities was utilised to raise awareness and maximise interest in participation. These included emails to all staff, posters throughout the department, cards with QH

codes, and face to face session at handover. Weekly reminders were sent to participants to promote app use.

## **Randomisation**

Participants were randomised into one of the two study arms with a 1:1 ratio at each study site to minimize selection bias. Randomisation was performed via a centralized randomisation website (<https://www.random.org>). The group allocation was concealed until interventions were assigned. Due to the nature of the intervention, participants were not blinded. Participant-created IDs were used to link survey data. Participant's emails and mobile phone numbers were collected separately and stored in separate files to avoid identifying participants and maintain blinding during data analysis to prevent detection bias.

## **Intervention**

The Headspace app® is a commercially available app however was provided to the study participants free-of-charge with the normal subscription covered by research grants. Based on previous studies participants were advised to practice daily, 10 minutes of guided mindfulness-meditation at their own convenience during the 4-week intervention period.<sup>20, 21</sup> The app was ranked as the top mindfulness app by two recent systematic reviews.<sup>22, 23</sup> Its effect on stress reduction and wellness promotion has been validated over multiple RCTs.<sup>14, 15</sup> Within the app, there are more than 50 meditation sessions available which vary from three to 20 minutes guided by an instructor. Participants could choose any sessions at their preferences to practice mindfulness during the intervention period.

## **Outcomes**

Survey data were collected via the secure online survey platform *Qualtrics*<sup>XM</sup>. Participants' demographic data (e.g. age, gender) were collected in the first survey. Data regarding app use patterns were collected post the intervention at T2 (for App group) and T4 (for Wait group).

Each survey contained four scales to measure stress, burnout, mindfulness awareness and well-being.

1. Stress as the primary outcome was measured by the Perceived Stress Scale (PSS).<sup>24</sup> PSS is a validated 10-item questionnaire assessing the frequency of perceived stressful feelings in the past month on a five-point scale (0= "never" to 4= "very often").<sup>24</sup> The total scores reflect low (0-13), moderate (14-26) and high levels of stress (27-40).<sup>24</sup> This tool is commonly used in measuring stress

levels and been used in numerous studies including those with health care professionals.<sup>25, 26</sup> In the current study, the PSS tool had a very good internal consistency reliability (Cronbach's alpha ( $\alpha$ ) = .89).

2. Maslach Burnout Inventory (MBI) consists of 22 questions on a five-point response scale (0= "never" to 4= "always").<sup>27</sup> It was designed to measure burnout from three subscales; emotional exhaustion (EE), depersonalisation (DP) and personal accomplishment (PA). The Cronbach alpha coefficient in this study was EE ( $\alpha$  = .90), DP ( $\alpha$  = .75) and PA ( $\alpha$  = .69).

3. Mindfulness Attention Awareness Scale (MAAS) consists of 15 questions measuring the frequency of a range of mindfulness states on daily basis on a six-point scale (1= "almost always", 6= "almost never").<sup>28</sup> In this study, the Cronbach alpha coefficient was .90.

4. Warwick-Edinburgh Mental Well-being Scale (WEMWBS) is a valid scale with 14 positive worded questions to measure the mental wellbeing of adults.<sup>29</sup> The scale measures an individual's positive feelings and thoughts in the last two weeks on a five-point scale (1= "none of the time" to 5= "all the time"). The Cronbach alpha coefficient was .93 in this study.

### **Sample size**

A sample size of 70 was calculated based on the primary outcome, stress, using G\*Power (version 3.1.9.7, 2020). A two-tailed alpha of .05 was assumed for all tests by considering Cohen's guidelines for small ( $d$  = 0.2-0.5), medium ( $d$  = 0.5-0.8) and large ( $d$  > 0.8) effects.<sup>30</sup> To detect a 3 (time)  $\times$  2 (group) interaction, it was assumed correlation among repeated measures of 0.3,<sup>31</sup> a medium effect size of 0.45<sup>14</sup> and a power of 0.80 ( $p$  < 0.05). Based on the higher figure for reported attrition rates (20-30%) from previous app studies,<sup>14, 15</sup> a total of 100 subjects were needed for the RCT.

### **Statistical analysis**

Results were analysed in SPSS Version 27 (IBM Corporation, Armonk, New York, USA) and are reported on both an intention-to-treat (ITT) and 'per-protocol' basis: (1) The ITT analysis included all participants who were randomised and did not withdraw consent directly after randomisation.<sup>32</sup> (2) The 'per-protocol' consisted only of participants who reported using the intervention for the entire intervention period. An alpha level of  $p \leq 0.05$  and two-sided tests were used.

Participant characteristic data was presented as descriptive statistics. Baseline differences of scale and categorical variables between groups were measured using independent-samples *t*-tests and Chi-square tests, respectively. Overall survey variables were summarised using means, standard deviations (SD) and confidence intervals (CI). The attrition rate ~~and intervention-adherence rate~~ between groups was also presented as descriptive statistics and Chi-square tests.

In addition to the direct comparison of T1-T3 across the intervention group and the control group, a combined database (App group (T1-T3), Wait group (T3-T5)) with integrated data of all participants at pre, post immediate and post 3-month time points was used to increase the sample size and statistical power in comparing the overall effectiveness of the intervention. In the integrated dataset the Wait group T3, T4 and T5 effectively became equivalent to T1, T2 and T3 for the App group.

### **Effectiveness**

The Linear Mixed Model (LMM) for repeated measures with *random intercept* was chosen to compare treatment differences over time due to its advanced approach to managing missing data by including incomplete cases in the analysis in longitudinal designs.<sup>33</sup> *Unstructured* covariance structure and *maximal likelihood* estimation were used to calculate variable estimates. Akaike's Information Criterion and CI were used to validate the fit of the models.<sup>34</sup> The effects of *time* and *group\*time* were also tested. The *time* effect measures the variable differences at each time point of measurements *within groups*. The *group\*time* effect measures the variable differences *between groups* at different time points. Cohen's *d* was used to measure the effect size.

## **RESULTS**

After screening for eligibility a total of 148 participants were randomised into either the App group (n=74) or the Wait group (n=74) (Figure 2). Both groups had similar retention of survey completion (App group: 47/74 (64%), Wait group: 49/74 (66%),  $\chi^2 (1) = 28.044$ ,  $p=0.258$ ) at the three-month post intervention assessment. There was no significant difference in retention rate among the two study sites (Site A: 73/106 (69%), Site B: 23/42 (56%),  $\chi^2 (1) = 19.53$ ,  $p=0.723$ ).

Table 1 presents the baseline demographic, job and work experience of both groups. The majority of participants were female (78%), nurses (59%), less than 40 years old (66%), and worked in a junior nursing or medical position (51%). The median years of ED experience were three years.

In total, 71 (48%) participants reported continuous app use for the entire intervention period. Participants from the App group (n=42) had a higher rate of app use compared with the Wait group (n=29) (59% vs. 41% respectively,  $\chi^2=9.6$ ,  $p=0.002$ ). The characteristics of meditation practice are summarised in Appendix 1. The most frequently self-reported app use was 1-3 times per week (41%) of 2-10 minute sessions (68%) at home (96%).

### **Effectiveness**

The means and SDs of all outcome variables of the App group (T1-T3) and the Wait group (T1-T5) at its original data collection points were listed in Appendix 2. There were improvements in all variables by comparing pre and post intervention periods where the Wait group was used as a control group without receiving any intervention (T1-T3). The improvement in stress levels is displayed in Figure 3.

Table 2 and Table 3 demonstrates *within-group effects* based on ITT analysis and per-protocol analysis.

### ***Intention-to-treat analyses***

Overall, there was a significant reduction in perceived stress *within-group* ( $F=15.70$  (2, 102),  $p<0.001$ ) over time. Similarly, burnout (EE ( $F=14.22$  (2, 106),  $p<0.001$ ), DP ( $F=3.62$  (2, 102),  $p=0.030$ ), PA ( $F=7.51$  (2, 100),  $p<0.001$ )), mindfulness ( $F=8.83$  (2, 103),  $p<0.001$ ) and wellness levels ( $F=10.71$  (2, 100),  $p<0.001$ ) were also improved *between T1 and T3* (Table 2). The overall *within-group* effect size of all variables were small between baseline and post immediate surveys; stress ( $d=0.45$ ), EE ( $d=0.33$ ), DP ( $d=0.23$ ), PA ( $d=0.36$ ), mindfulness ( $d=0.30$ ) and wellness ( $d=0.38$ ).

### ***Per-protocol analysis***

Likewise, all variables improved significantly *between T1 and T3*; stress ( $F=18.30$  (2, 68),  $p=0.000$ ), burnout (EE ( $F=13.26$  (2, 71),  $p<0.001$ ), DP ( $F=4.59$  (2, 68),  $p<0.001$ ), PA ( $F=6.69$  (2, 67),  $p=0.002$ )), mindfulness ( $F=11.95$  (2, 67),  $p<0.001$ ) and wellness ( $F=11.24$  (2, 66),  $p<0.001$ ) (Table 3). The overall *within-group* effects of most variables were small between baseline and post immediate, apart from stress ( $d=0.63$ ) and wellness ( $d=0.54$ ) which had moderate effects.

## **DISCUSSION**

In summary, the main findings of the study are that regular use of self-orientated, smartphone-guided mindfulness app for between 2 and 10 minutes for 4 weeks can significantly reduce stress and burnout as well as promote mindfulness and wellbeing of ED staff. Ultimately, effective stress management may also have clinical significance in promoting staff retention, productivity, career longevity as well as impact on patient care. Using an available smartphone app means staff with access to a smartphone can easily access this convenient stress management intervention. In future, this simple, effective self-help intervention can be used as one element of a holistic treatment package for ED staff to increase individual's resilience in managing stress.

The digital mindfulness intervention has multiple advantages and can be considered an ideal intervention for stress reduction due to its convenience, accessibility and anonymity. The digital intervention might be considered as a more suited way over other stress coping strategies (e.g. socialise with family or friends) due to social distance requirements during the COVID-19 pandemic. While organisational services and programs could be difficult to access during a pandemic or impersonal, the app can be used at any time, in any place and can be individualised to the user's needs.

The baseline score indicates that participants had a moderate level of stress before they received the intervention. Baseline burnout scores also highlight that participants in both groups reported higher scores of EE, DP, PA than other recently published ED studies.<sup>35, 36</sup> Mean mindfulness score was similar to the findings in other healthcare workers related studies.<sup>37, 38</sup> The wellness score at baseline was 46.90, which reflects average mental wellbeing.<sup>39</sup>

The current study demonstrated that an app guided mindfulness practice had a significant positive effect on all outcome variables in both ITT and per-protocol analyses. The Cohen's *d* effect size of stress reduction was between small and moderate at both one month and three months follow up in our study, which is similar to the reported moderate effect in a systematic review of online mindfulness studies among the general population.<sup>13</sup>

Maintaining user engagement and continuous mindfulness practice were expected challenges with the mindfulness app intervention. The percentage of participants who were able to maintain regular app use for the entire intervention period in the current study was similar to previous studies utilising a mindfulness app intervention among healthcare workers.<sup>20, 40</sup> In contrast, its attrition rate was higher

than previous studies.<sup>14, 15</sup> The higher attrition rate in the SMART trial may be due to the study participants were busy ED clinicians who were unable to commit to repeated surveys of the longitudinal study. Participants reported moderate levels of stress at baseline, which could be considered reasons and motivation to learn mindfulness. Despite this fact, a contrasting finding was that only 48% of participants accessed the app, which suggests high stress was not a sufficiently motivating factor for app use. This finding has been reported previously as behaviour change is a complex process and risk awareness is not enough to motivate behaviour changes.<sup>41</sup> These findings provide important evidence for future research and wellness promotion practice.

It is worth noticing that the usage of the app for the entire intervention period in the Wait group was lower than that of the App group. There are several reasons that this may have been the case. The intervention for the Wait group was delivered over the early outbreak of the COVID-19 pandemic in Australia. It is plausible that participants in the Wait group experienced higher pressure under unprecedented circumstances. Some participants might have been overwhelmed and did not have the time or mental capacity to learn a new skill when they were under high pressure and dealing with uncertainty. Although participants had intentions to manage their stress, some participants in the Wait group may have lost interest in the study or were unable to translate intention into action after waiting five months. In short, low intervention engagement of the Wait group reflects the challenge of a longitudinal study and implementing digital mindfulness practice into the daily life of frontline ED healthcare workers during the pandemic.

Due to the negative consequences of burnout on ED staff and patient care, it is vital to address occupational stress and burnout in every direction possible to promote patient safety and staff longevity. It is important to point out that despite the study focusing on fostering individual wellbeing by ameliorating an individual's resilience towards workplace stress and place stress management ownership on staff, it does not replace the importance of other interventions in addressing issues in the organisation that are the root causes of occupational stress and burnout.<sup>5</sup> Although the mindfulness app can be utilised as a stand-alone wellness promotion tool, future studies or organisational projects should consider combining these types of interventions with broader organisation programs to foster staff longevity and employee wellbeing.

## **Limitations**

There are recognised limitations of the study. The self-selection process during recruitment has an inherent bias as those who participated in the study are potentially more aware of their stress levels and are self-motivated to trial a new way to manage the stress. All study outcomes were self-reported without objective measurements (e.g. cortisone). Furthermore, the study is limited by sole reliance on participant self-reported app engagement measures. As the study had a high attrition rate, it is possible the study did not capture the participants who did not receive benefits from mindfulness practice. Additionally, due to limited time and budget to run this research, the study was unable to research the long term effects. Regardless of these limitations, the findings of this study are likely to have a meaningful impact on stress reduction and wellness promotion of ED healthcare workers.

### **Implications**

To establish an engaging working environment and employee wellbeing-focused organisational culture, preventative measurements are needed to foster staff wellbeing. Mindfulness interventions in a digital format available at no cost or a low cost could be used within the 'toolbox' for stress reduction. It can support healthcare workers who are generally busy and hard-to-reach by traditional face-to-face interventions. This type of intervention could have a significant impact on staff wellbeing especially during difficult times like the COVID-19 pandemic where isolation is required and wellness intervention is needed. Apart from providing staff with an app, using information sessions regarding optimal use of the app or introducing regular group mindfulness sessions at the workplace at an early stage might be an effective way to increase human contact, engage staff to acquire this new skill, as well as overcome low adherence issue.

### **CONCLUSION**

The results of this study suggest that a digital mindfulness intervention is an effective stress management tool for ED staff. Even though there was a low intervention engagement, participants who chose to use the app found it was useful in stress reduction. This flexible and easily accessible tool with promising outcomes, can be used as a employee self-assistance intervention in addition to existing organisation support services to reach a wide cohort of healthcare workers who work in stressful environments. Future research should focus on extending existing knowledge regarding how to better support participants to improve adherence, engagement and acceptability of the digital mindfulness intervention.

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## Authors' contributions

HX, RE and AT designed the study. HX collected and analysed data and drafted the initial manuscript. RE, AT and KK reviewed and revised the manuscript. All authors approved the final manuscript and agree to be accountable for all aspects of the work.

## Competing interests

Nil to declare.

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## Tables

**Table 1. Characteristics of the two groups at baseline**

	Overall (n=148)	App Group (n=74)	Wait Group (n=74)	Chi-square test between groups $\chi^2$ , p
<b>Age, n (%)</b>				0.977, p0.913
• < 30 years	61 (41%)	30 (40%)	31 (42%)	
• 30-39 years	37 (25%)	19 (26%)	18 (24%)	
• 40-49 years	30 (21%)	16 (22%)	14 (19%)	
• ≥ 50years	20(13%)	9(12%)	11(15%)	
<b>Gender, n (%)</b>				0.975, p0.323
• Male	33 (22%)	14 (19%)	19 (26%)	
• Female	115 (78%)	60 (81%)	55 (74%)	
<b>Occupation, n (%)</b>				6.706, p=0.152
• Nurse	87 (59%)	46 (62%)	41 (55%)	
• Doctor	35 (23%)	17 (23%)	18 (25%)	
• Allied health staff	14 (10%)	3 (4%)	11 (15%)	
• Administrative staff	11 (7%)	7 (10%)	4 (5%)	
• Other staff	1 (1%)	1 (1%)	0 (0%)	
<b>Years of clinical experience, median (IQR), range</b>	7 (13.0), (0-46)	7 (12.8), (0-40)	7 (13.5), (0-46)	
<b>Years of ED experience, median (IQR), range</b>	3 (6.1), (0-31)	4 (6.8), (0-30)	3 (5.4), (0-31)	
<b>Full time equivalent, n (%)</b>				0.272, p=0.873
• Part time (≤ 0.5)	10 (7%)	5 (7%)	5 (7%)	
• Part time (0.6-0.9)	83 (56%)	40 (54%)	43 (58%)	
• Full time (1.0)	55 (37%)	29 (39%)	26 (35%)	

Note:

<sup>†</sup> Junior nurses include Assistant Nurse, enrolled Nurse and Registered Nurse.

<sup>‡</sup> Senior nurses include Clinical Nurse, Clinical Nurse Facilitator, Clinical Nurse Consultant, Nurse Unit Manager, Nurse Educator and Nurse Practitioner.

<sup>§</sup> Junior doctors include Intern, Junior House Officer and Senior House Officer.

<sup>¶</sup> Senior doctors include Registrar and Consultant.

IQR= interquartile range

**Table 2. Within-group effects and analysis of outcome variables over three time points (Intention-to-treat analysis)**

	Groups	T1 (pre-intervention)*	T2/T4 (post immediate)*	T3/T5 (post 3 month)*					
Number of participants (n)	App group	74	52	47	-	-	-	-	-
	Wait group	63	52	49	-	-	-	-	-
	Overall	137	104	96	-	-	-	-	-
Variables		T1 Mean (SD) [95% CI]	T2 Mean (SD) [95% CI]	T3 Mean (SD) [95% CI]	t-test of group difference at T1: <i>t, p</i>	Cohen's <i>d</i> (Within-group)		LMM analysis: <i>F(df<sub>1</sub>, df<sub>2</sub>), p</i>	
						T2 vs. T1	T3 vs. T1	Time	Group * Time
Stress	App group	18.36(6.73) [16.81 to 19.92]	14.23(5.99) [12.56 to 15.90]	15.17(6.35) [13.31 to 17.03]		-0.65	-0.49	<b>15.70 (2, 104), p=0.000</b>	2.45 (3, 110), p=0.065
	Wait group	18.08(6.20) [16.52 to 19.64]	16.71(5.40) [15.21 to 18.22]	15.14(5.56) [13.54 to 16.74]		-0.24	-0.50		
	Overall	18.23(6.47) [17.14 to 19.33]	15.47(5.81) [14.34 to 16.60]	15.16(5.93) [13.95 to 16.36]	0.258, p>0.05	-0.45	-0.48		
Burnout	App group								
	• EE	33.62(11.98) [30.85 to 36.40]	29.56(11.98) [26.16 to 32.96]	30.93(11.57) [27.50 to 34.37]		-0.34	-0.23	<b>14.22 (2, 106), p=0.000</b>	2.18 (3, 113) (p=0.095)
	• DP	13.91(5.86) [12.55 to 15.26]	12.50(6.24) [10.73 to 14.27]	13.48(6.28) [11.61 to 15.34]		-0.23	-0.07		
	• PA	43.66(6.35) [42.19 to 45.13]	46.66(5.57) [45.08 to 48.24]	45.46(5.46) [43.84 to 47.08]		0.50	0.30	<b>7.51 (2, 100), p=0.001</b>	0.69 (3, 104), p=0.559
	Wait group								
	• EE	34.90(11.62) [31.93 to 37.88]	31.17(10.31) [28.30 to 34.04]	29.02(10.93) [25.85 to 32.19]		-0.34	-0.52		
	• DP	15.69(6.24) [14.09 to 17.29]	14.08(6.22) [12.35 to 15.81]	13.58(5.91) [11.87 to 15.30]		-0.26	-0.35		
	• PA	43(7.33) [41.12 to 44.88]	44.62(5.75) [43.01 to 46.22]	45.33(6.82) [43.35 to 47.31]		0.25	0.33		
	Total								
	• EE	34.20(11.79) [32.19 to 36.21]	30.38(11.13) [28.20 to 32.57]	29.96(11.23) [27.66 to 32.26]	-0.627, p>0.05	-0.33	-0.37		
	• DP	14.71(6.08) [13.68 to 15.75]	13.30(6.25) [12.08 to 14.53]	13.53(6.06) [12.29 to 14.77]	-1.709, p>0.05	-0.23	-0.19		

	• PA	43.36(6.79) [42.21 to 44.52]	45.62(5.73) [44.49 to 46.74]	45.39(6.16) [44.13 to 46.66]	0.562, p>0.05	0.36	0.31		
Mindfulness	App group	3.62(0.88) [3.42 to 3.83]	3.92(0.73) [3.71 to 4.12]	3.87(0.84) [3.62 to 4.12]		0.37	0.29	<b>8.83 (2, 103), p=0.000</b>	0.21 (3, 113), p=0.891
	Wait group	3.60(0.87) [3.38 to 3.82]	3.81(0.83) [3.58 to 4.05]	3.89(0.87) [3.63 to 4.14]		0.25	0.33		
	Overall	3.61(0.87) [3.46 to 3.76]	3.86(0.78) [3.71 to 4.02]	3.88(0.85) [3.70 to 4.05]	0.156, p>0.05	0.30	0.31		
Wellness	App group	46.51(9.90) [44.22 to 48.81]	50.84(8.27) [48.49 to 53.19]	50.04(8.33) [47.57 to 52.52]		0.47	0.39	<b>10.71 (2, 100), p=0.000</b>	0.53 (3, 108), p=0.665
	Wait group	47.38(7.98) [45.33 to 49.42]	49.60(8.24) [47.30 to 51.89]	51.08(8.51) [48.61 to 53.55]		0.27	0.45		
	Overall	46.90(9.06) [45.36 to 48.45]	50.21(8.24) [48.59 to 51.82]	50.57(8.39) [48.86 to 52.29]	-0.550, p>0.05	0.38	0.42		

Note:

\*To minimise data in the table, the survey findings of T1 and T2 for Wait group were not included. T3-T5 findings of Wait group are included under the pre-intervention, post immediate and post 3 month time points in this table.

Standard division= SD

LMM = Linear Mixed Model

Emotional exhaustion= EM

Depersonalisation= DP

Personal accomplishment= PA

**Table 3. Within-group effects and analysis of outcome variables over three time points (Per-protocol analysis)**

	Groups	T1 (pre-intervention)*	T2/T4 (post immediate)*	T3/T5 (post 3 month)*					
Number of participants (n)	App group	42	42	37	-	-	-	-	-
	Wait group	29	29	27	-	-	-	-	-
	Overall	71	71	64	-	-	-	-	-
Variables		T1 Mean (SD) [95% CI]	T2 Mean (SD) [95% CI]	T3 Mean (SD) [95% CI]	t-test of group difference at T1: <i>t, p</i>	Cohen's <i>d</i> (Within-group)		LMM analysis: <i>F(df<sub>1</sub>, df<sub>2</sub>), p</i>	
						T2 vs. T1	T3 vs. T1	Time	Group * Time
Stress	App group	19.38(5.8) [17.56 to 21.20]	14.64(6.13) [12.73 to 16.55]	15.05(6.20) [12.99 to 17.12]		-0.79	-0.72	<b>18.30 (2, 68), p=0.000</b>	1.17 (3, 69), p=0.328
	Wait group	18.21(6.26) [15.82 to 20.59]	16.03(5.02) [14.13 to 17.94]	14.22(5.38) [12.09 to 16.35]		-0.38	-0.68		
	Overall	18.90(6.00) [17.48 to 20.32]	15.21(5.70) [13.86 to 16.56]	14.70 (5.84) [13.24 to 16.16]	0.809, p>0.05	-0.63	-0.71		
Burnout	App group								
	• EE	34.29(12.07) [30.52 to 38.05]	28.55(12.54) [24.64 to 32.45]	30.51(12.18) [26.45 to 34.57]		-0.47	-0.31	<b>13.26 (2, 71), p=0.000</b>	1.01 (3, 70), p=0.394
	• DP	13.36(5.52) [11.64 to 15.08]	11.79(6.06) [9.90 to 13.67]	13.16(6.47) [11.00 to 15.32]		-0.27	-0.03	<b>4.59 (2, 68), p=0.013</b>	2.47 (3, 69), p=0.069
	• PA	44.57(5.51) [42.85 to 46.29]	47.07(5.31) [45.42 to 48.73]	45.84(5.05) [44.15 to 47.52]		0.46	0.24	<b>6.69 (2, 67), p=0.002</b>	1.46 (3, 67), p=0.232
	Wait group								
	• EE	35.55(11.35) [31.23 to 39.87]	31.31(9.81) [27.58 to 35.04]	30.54(10.77) [26.19 to 34.89]		-0.40	-0.45		
	• DP	16.55(6.08) [14.24 to 18.86]	14.24(6.05) [11.94 to 16.54]	14.42(6.08) [11.97 to 16.88]		-0.38	-0.35		
	• PA	42.69(5.54) [40.58 to 44.80]	44.69(4.59) [42.94 to 46.44]	44.65(6.37) [42.08 to 47.23]		0.39	0.33		
	Overall								
	• EE	34.80(11.72) [32.03 to 37.58]	29.68(11.51) [26.95 to 32.40]	30.52(11.53) [27.62 to 33.43]	-0.450, p>0.05	-0.44	-0.37		
	• DP	14.66(5.93) [13.26 to 16.07]	12.79(6.13) [11.34 to 14.24]	13.68(6.29) [12.10 to 15.27]	-2.299, p<0.05	-0.31	-0.16		

	• PA	43.80(5.56) [42.49 to 45.12]	46.10(5.13) [44.88 to 47.31]	45.35(5.61) [43.94 to 46.76]	1.412, p>0.05	-0.43	-0.28		
Mindfulness	App group	3.66(0.89) [3.38 to 3.93]	3.99(0.66) [3.78 to 4.20]	3.88(0.87) [3.58 to 4.17]		0.42	0.25	<b>11.95 (2, 67), p=0.000</b>	1.12 (3, 69), p=0.346
	Wait group	3.39(0.82) [3.08 to 3.71]	3.82(0.82) [3.51 to 4.13]	3.87(0.75) [3.57 to 4.18]		0.52	0.57		
	Overall	3.55(0.87) [3.34 to 3.75]	3.92(0.73) [3.75 to 4.09]	3.88(0.82) [3.67 to 4.08]	1.268, p>0.05	0.46	0.39		
Wellness	App group	46.21(9.09) [43.38 to 49.05]	51.10(8.30) [48.51 to 53.68]	50.35(8.03) [47.68 to 53.03]		0.56	0.48	<b>11.24 (2, 66), p=0.000</b>	0.21 (3, 68), p=0.893
	Wait group	47.72(7.69) [44.80 to 50.65]	51.72(8.51) [48.49 to 54.96]	51.73(8.10) [48.46 to 55.00]		0.49	0.51		
	Overall	46.83(8.52) [44.81 to 48.85]	51.35(8.33) [49.38 to 53.32]	50.92(8.02) [48.90 to 52.94]	-0.732, p>0.05	0.54	0.49		

Note:

\*To minimise data in the table, the survey findings of T1 and T2 for Wait group were not included. T3-T5 findings of Wait group are included under the pre-intervention, post immediate and post 3 month time points in this table.

Standard division= SD

LMM = Linear Mixed Model

Emotional exhaustion= EM

Depersonalisation= DP

Personal accomplishment= PA

## Figure legends

Figure 1: Study design and timeline

Figure 2: CONSORT Flow Diagram

Figure 3: Changes in stress by group (Intention-to-treat analysis)

## Appendix legends

Appendix 1: Characteristics of meditation practice

Appendix 2: Baseline and post-intervention scores of outcome variables over five time points (Intention-to-treat analysis)

**Figure 1: Study design and timeline**

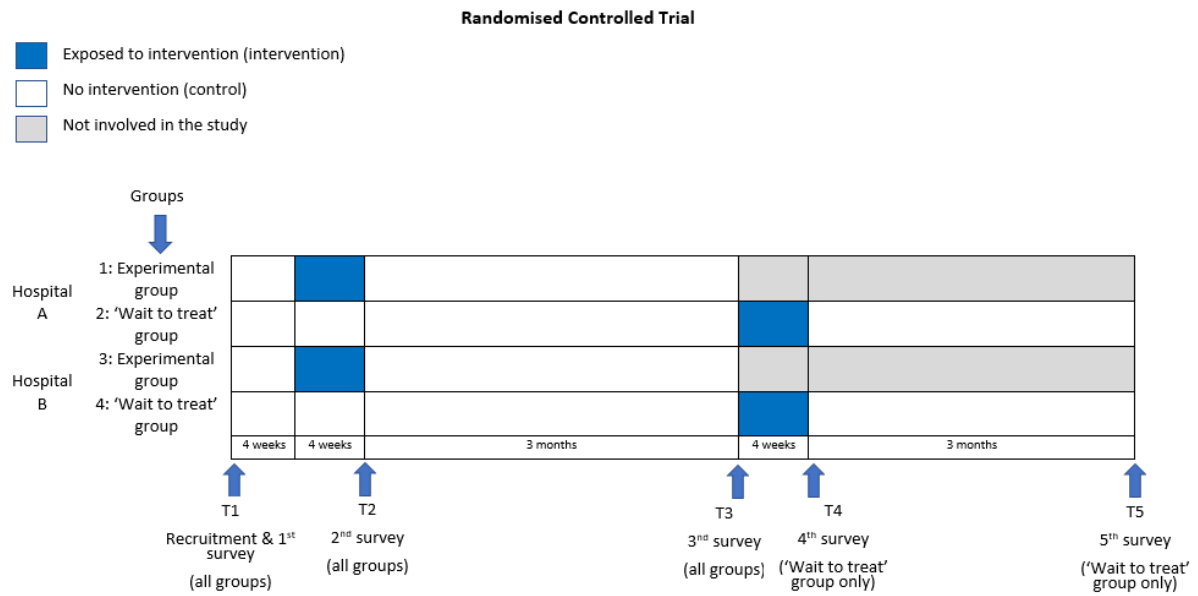
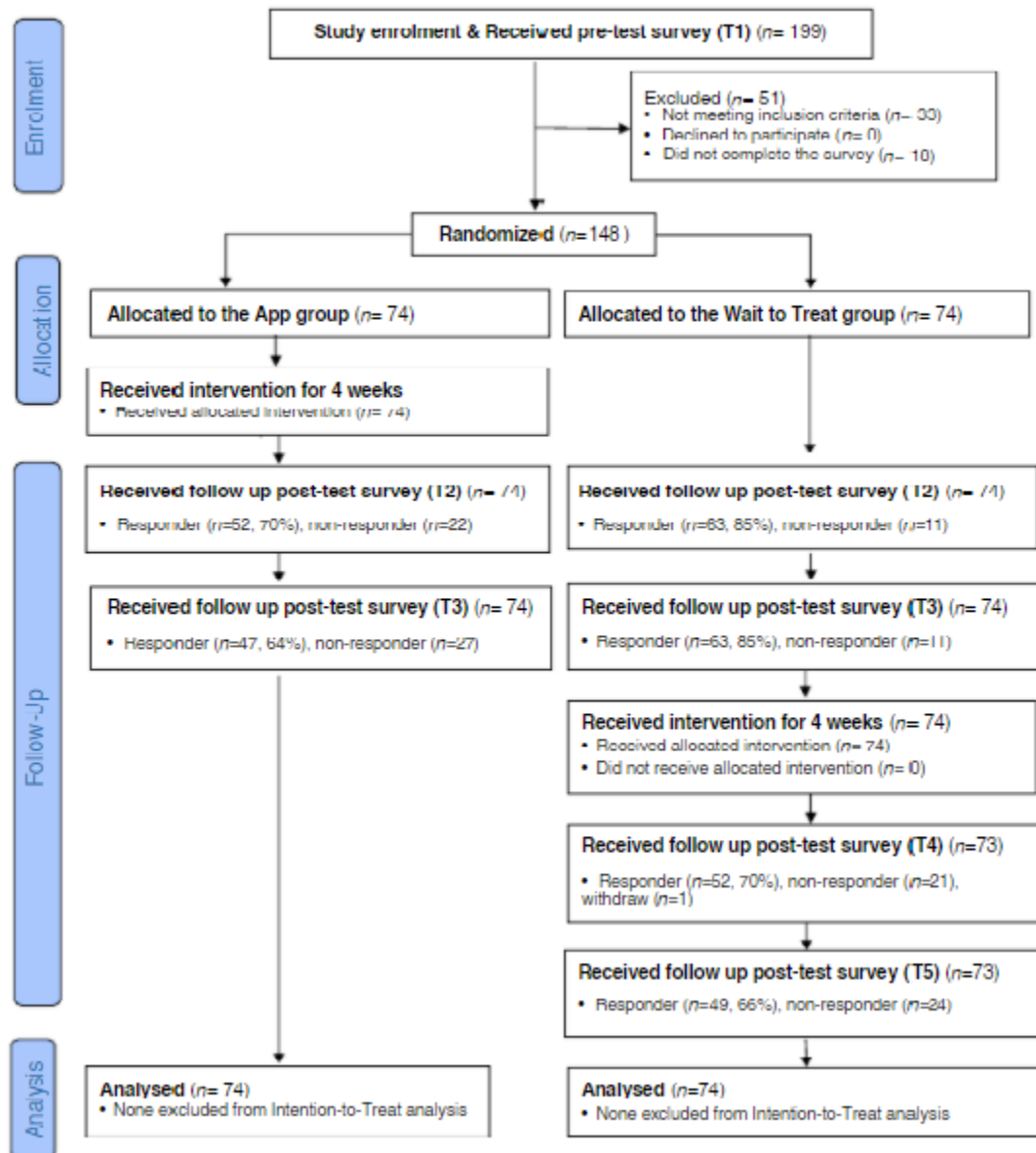
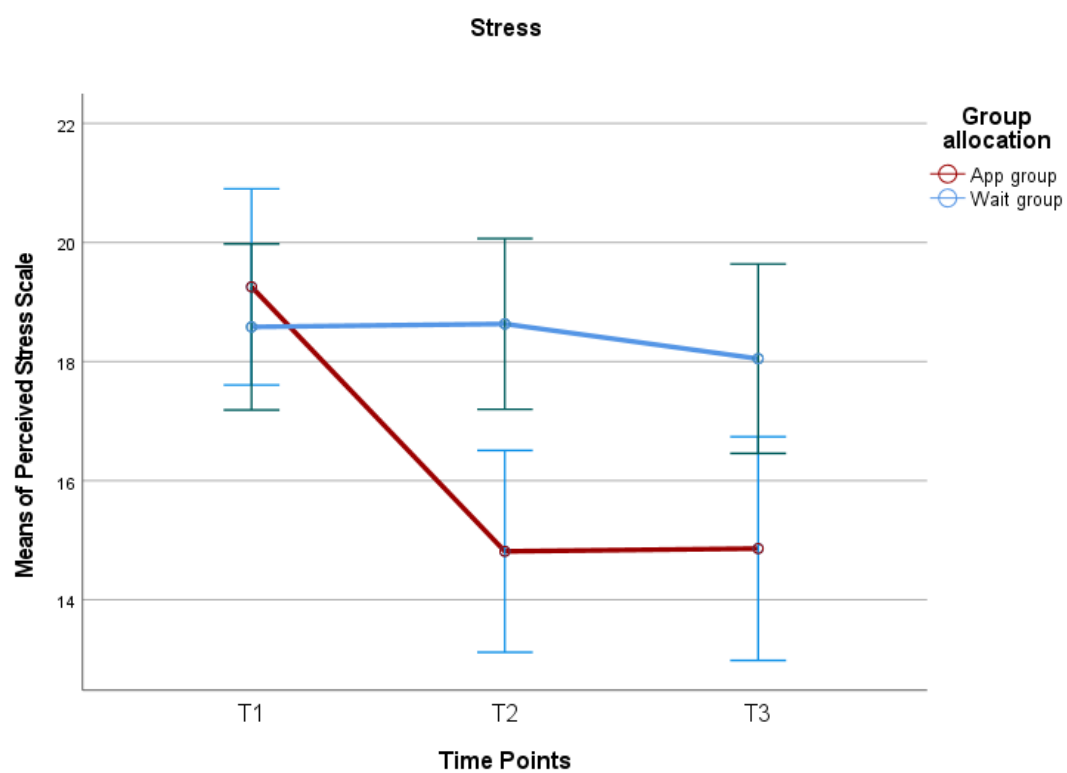


Figure 2. CONSORT flow diagram



**Figure 3: Changes in stress by group (Intention-to-treat analysis)**



Appendix 1: Characteristics of meditation practice

	Overall	App group	Wait to treat Group	Chi square test between groups $\chi^2$ , p
Total participants, n	148	74	74	
Participants continuously used the app for the entire intervention period, n (%)	71 (48%)	42 (57%)	29 (39%)	
<b>Practice frequency, n (%)</b>				5.845, p>0.05
• At least once daily	9 (13%)	2 (5%)	7 (24%)	
• More than 3 times per week	14 (20%)	9 (22%)	5 (17%)	
• 1-3 times per week	29 (41%)	19 (45%)	10 (35%)	
• Less than once per week	19 (26%)	12 (28%)	7 (24%)	
<b>Length of each session, n (%)</b>				5.70, p>0.05
• ≤ 2 minutes	1 (1%)	1 (2%)	0 (0%)	
• 2-10 minutes	48 (68%)	32 (77%)	16 (55%)	
• 11-20 minutes	18 (26%)	8 (19%)	10 (35%)	
• 21-60 minutes	3 (4%)	1 (2%)	2 (7%)	
• ≥ 1 hour	1 (1%)	0 (0%)	1 (3%)	
<b>Location</b>				0.763, p>0.05
• At work	2 (3%)	1 (2%)	1 (3%)	
• At home	68 (96%)	40 (96%)	28 (97%)	
• Other place	1 (1%)	1 (2%)	0 (0%)	

**Appendix 2: Baseline and post-intervention scores of outcome variables over five time points  
(Intention-to-treat analysis)**

Variables	Groups	T1 Mean (SD)	T2 Mean (SD)	T3 Mean (SD)	T4 Mean (SD)	T5 Mean (SD)
Number of participants (n)	App group	74	52	47	-	-
	Wait group	74	63	63	52	49
Stress	App group	18.36(6.73)	14.23(5.99)	15.17(6.35)	-	-
	Wait group	18.61(5.16)	18.44(5.45)	18.08(6.20)	16.71(5.40)	15.14(5.56)
	Between-group differences in mean	0.25	4.21	2.91	-	-
Burnout	App group				-	-
	• EE	33.62(11.98)	29.56(11.98)	30.93(11.57)	-	-
	• DP	13.91(5.86)	12.50(6.24)	13.48(6.28)	-	-
	• PA	43.66(6.35)	46.66(5.57)	45.46(5.46)	-	-
	Wait group					
	• EE	35.09(10.58)	36.06(11.18)	34.90(11.62)	31.17(10.31)	29.02(10.93)
	• DP	15.72(6.55)	16.90(6.69)	15.69(6.24)	14.08(6.22)	13.58(5.91)
	• PA	43.99(5.73)	42.46(6.90)	43.00(7.33)	44.62(5.75)	45.33(6.82)
	Between-group differences in mean					
	• EE	1.47	6.5	3.97	-	-
	• DP	1.81	4.4	2.21	-	-
	• PA	0.33	-4.2	-2.46	-	-
Mindfulness	App group	3.62(0.88)	3.92(0.73)	3.87(0.84)	-	-
	Wait to treat group	3.56(0.77)	3.61(0.90)	3.60(0.87)	3.81(0.83)	3.89(0.87)
	Between-group differences in median	-0.06	-0.31	-0.27	-	-
Wellness	App group	46.51(9.90)	50.84(8.27)	50.04(8.33)	-	-
	Wait to treat group	46.96(7.04)	46.56(7.28)	47.38(7.98)	49.60(8.24)	51.08(8.51)
	Between-group differences in median	0.45	-4.28	-2.66	-	-

*Note:*

*Standard division= SD*

*Emotional exhaustion= EM*

*Depersonalisation= DP*

*Personal accomplishment= P*