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Investigating the effectiveness of a mobile-based mindfulness application on psychological well-being and rumination.

Jasmine McGuane

Supervised by: Elaine Reeves   April 2017

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ABSTRACT

Research has frequently identified that students are vulnerable to mental health issues which is becoming a common problem (Andrew and Wilding, 2004), therefore intervention for such is essential. Anxiety, depression and rumination are three factors that negatively influence the psychological well-being of students and mindfulness has shown to improve these factors (Hofmann et al., 2010; Gaynor et al., 2014). Mindfulness has offered promising results for improvement of psychological well-being, however the duration of mindfulness interventions is impractical for students. The present study explored the effectiveness of a mobile-based mindfulness application on the psychological well-being of students. Forty students were randomly assigned to either a mindfulness condition (n = 20) or an active control condition (n = 20) to investigate whether a short-term mindfulness intervention improves trait mindfulness and reduces anxiety, depression and rumination over a ten-day period. The mindfulness condition experienced a significant increase in self-reported trait mindfulness and significant decrease in anxiety, depression and rumination from pre-post intervention. No significant changes in any of the variables were found for the control condition. The present study offers theoretical directions for using mobile-based interventions, whilst addressing implications for future research.

KEY WORDS:	MOBILE-BASED MINDFULNESS APPLICATION	TRAIT-MINDFULNESS	ANXIETY	DEPRESSION	RUMINATION

Introduction

Mindfulness is a scientific concept that has flourished for psychological and medical research over the last decade (Brown et al., 2007). The origins of mindfulness lie in Buddhism and contemplative traditions (Kabat-Zinn, 2003) and is described as "paying attention in a particular way; on purpose, in the present moment and non-judgmentally" (Kabat-Zinn, 1994: 4). Mindfulness signifies a conceptual state characterised by non-judgemental awareness of the current moment experience, including individual sensations, feelings, bodily states, awareness, and the environment, whilst being open, curious and accepting (Bishop et al., 2004; Kabat-Zinn, 2003). Mindfulness involves formal and informal practice; formal practice includes breath-focused attention, shifting attention through sensual modalit

ies, body-scan paying attention to the consciousness of sensory experience, examining moment-to-moment experiences, walking meditation, eating meditation and yoga. Informal practice includes momentary pauses throughout the day involving consciously shifting attention to current moment awareness (Goldin and Gross, 2010). Research supports the claim that mindfulness practiced widely has beneficial effects on physical and mental health (Tang et al., 2015).

When individuals engage in mindfulness-based interventions (MBI's) it is assumed that their immediate experience of being mindful increases. Also, it is assumed that positive effects translate into lasting effects by being mindful everyday (trait mindfulness) compared to immediate experiences of being mindful (state mindfulness) (Kiken et al., 2015). Several studies have found that trait-mindfulness contributes to improved psychological well-being (Shahar et al., 2010; Moss et al., 2012; Shapiro et al., 2011). Research has also found that state and trait-mindfulness are not significantly correlated together and should be investigated separately (Thompson and Waltz, 2007).

Mindfulness-based stress reduction (MBSR) is a widely-used mindfulness training aimed to reduce psychological distress and enhances quality of life involving the practice of mindfulness techniques (Kabat-Zinn, 1982). MBSR is typically an eight-week programme, developed by Jon Kabat-Zinn, in which individuals commit to eight weekly (2.5-hour long classes), one seven-hour 'mindfulness day' and forty-five minutes a day of daily mindfulness. Many studies have found positive effects for using MBSR for preventing a relapse in depression (Shapiro et al., 2005), stress and anxiety (Praissman, 2008) and lowering psychological distress in students (Rosenzweig et al., 2003). MBSR research allows clinical insight for those suffering associations with physical, mental and psychiatric disorders and individuals can alter dysfunctional thinking and behaviours (Grossman et al., 2004). Although studies have reported positive effects of MBSR, it is unclear whether these outcomes are attributed to changes in mindfulness as these studies have been inconsistent due to a lack of an active control condition, which is appropriate for such study (Nyklíček and Kuijpers, 2008). However, enhanced psychological improvements for individuals using MBSR has been found therefore, there is support for such interventions.

Additionally, mindfulness-based cognitive therapy (MBCT) is a combination of features of cognitive behavioural therapy (Beck et al., 1979) with aspects of the MBSR programme (Kabat-Zinn, 1990). MBCT allows individuals to withdraw from automatic routines, such as ruminative thought patterns and programs are eight, weekly, two-hour group-training sessions and includes daily homework exercises

(Teasdale et al., 2000). Many studies have found positive effects of using MBCT to treat depression and anxiety (Finucane and Mercer, 2006; Ma and Teasdale, 2004; Bieling et al., 2012). These studies provide evidence that MBCT offers a cost-efficient psychological method to treat depression and anxiety. However, there are some limitations to consider; a significant influence for MBCT happens only between those with at least three previous episodes of depression. Therefore, further research is required to examine specific benefits of MBCT (Burchett, 2010).

Furthermore, Fjorback et al. (2011) conducted a meta-analysis reviewing the evidence for MBSR and MBCT of seventy-two articles. Evidence supports that MBSR improves mental health and MBCT prevents depressive relapse. Overall, studies indicated medium effect sizes however, there was a lack of active control groups in several studies. Future randomised control trials should apply including active treatment for comparison. While research has found that mindfulness practice through MBI's is effective, this is lengthy and costly, therefore it is important to examine the efficiency of short-term interventions. For example, Zeidan et al. (2010) found that a four-day mindfulness intervention had significant effects for cognitive tasks. However, no specific benefits were found for mood. Although, this is the first study to establish that four days of mindfulness training can improve cognitive abilities, the effects of short-term interventions need investigating further for mood.

Consequently, mindfulness-based mobile applications (MBMA's) may potentially be an alternative method for MBI's. Though mindfulness is an effective method for improving psychological well-being, finding a mindfulness intervention that suits all individuals is challenging (Geraghty et al., 2013). Mobile health is emerging in health practice as applications create better opportunities through wider access. There is evidence for face-to-face MBI's having a positive effect (Fjorback et al., 2011), however, it is uncertain whether MBMA's can provide similar benefits.

Plaza et al. (2013) conducted a meta-analysis related to MBMA's and found that MBMA's were of interest to some people however, this study shows a lack of evidence supporting the usefulness and effectiveness of those applications. Also, no randomised control trials were used to evaluate the impact of these applications on mindfulness training. Furthermore, Mani et al. (2015) evaluated the quality of MBMA's using rating scales. Five hundred and sixty applications were reviewed and high levels of ratings for the Headspace, Smiling Mind, iMindfulness and Mindfulness Daily applications were found. The study used a multidimensional mobile-application rating scale, which provides a reliable measure of application quality. However, the review only tests ratings of the applications and does not assess the effectiveness of mindfulness. Also, many of these applications claim to be mindfulness-related; however, most are meditation timers, or reminders.

Howells et al. (2016) conducted a randomised control trial of a MBMA to improve well-being. Results showed a significant increase in positive affect and reduced depressive symptoms. However, no significance was found in life satisfaction. This found support that MBMA's significantly enhanced elements of well-being. However, the experimental condition completed an empirically-based mindfulness intervention (an application called Headspace) and the control condition completed a neutral task (an application called Catch Notes outlining what they did on each day). Therefore, the control condition was not closely linked with the experimental condition.

Furthermore, anxiety and depression is a common interest in mindfulness research due to its outcomes on psychological well-being. The American Psychiatric Association (APA) states that anxiety is future oriented, related to alertness of future danger and avoidant behaviours and that depressive disorders feature feelings of sadness, emptiness and cognitive changes that affect the capacity to function (APA, 2013). Hofmann et al. (2010) conducted a meta-analysis to review the impact of MBSR for anxiety and mood symptoms. A large effect size suggests that MBSR improved anxiety and depression levels from pre-test to post-test treatment; suggesting that MBSR is a reliable intervention for treating anxiety and depression. However, in this analysis, when active control conditions were used, MBSR did not have an effect on depression or anxiety. The lack of randomised clinical trials with active control groups restricts the provision for the effectiveness of MBSR (Toneatto and Nguyen, 2007).

Additionally, the Response Styles Theory suggests rumination is characterised by self-reflection (Morrow and Nolen-Hoeksema, 1990) and refers to repetitive thinking about negative thoughts, feelings, and situations (Smith and Alloy, 2009). Mindfulness theory suggests that MBCT prevents depression by decreasing ruminative thinking. MBCT aims to address reactive thought processes through encouraging people to recognise when their mood is declining and adapt a non-ruminative mind-set which allows individuals to discover these thoughts and feeling patterns (Segal et al., 2002). Despite the effectiveness of this methodology in preventing depression relapse, the approach has received little attention (Raes and Williams, 2010). Gaynor (2014) conducted a meta-analysis of mindfulness-based psychological treatments for rumination which examined whether there is any evidence from treatment research supporting MBI's effect on ruminative clinical levels. Gaynor (2014) examined eleven trials using MBI's and assessed decreases in rumination using self–report measures. Ten of the studies reported positive results for rumination. This provides levels of clinical implications that mindfulness can reduced ruminative thinking. However, these results indicate a positive effect while these were small effect sizes and were not compared to active controls. Therefore, it is difficult to recommend MBI's for clinical rumination due to insufficient evidence and further research is recommended to examine the effect of MBI's on rumination using an active control group.

Such research has found that mental health interventions should be applied to vulnerable populations to protect them against mental health issues (Seligman et al., 2005). Consequently, there has been an increase in the number of students consulting mental health services which has led to concerns about the growing relationship between students having poor mental health (Andrew and Wilding, 2004). Although students have counselling support, they are not often used (Eisenberg et al., 2007) and student mental health issues could turn to long-term mental health issues (Shapiro et al., 1998). Jain et al. (2007) found positive effects for using MBSR for students for one month, as rumination and distraction decreased for students. However, this study used group exercise's which may have resulted in the findings by the promotion of social support from peers and students found MBSR was too lengthy. There has been an increasing interest from academics and clinicians in using MBMA's to deliver health behavioural interventions for students as they are existing users of mobile applications. University studies found that young adults have a high interest in applications that attempt to support health-related

behaviour change. Students reported immediate effects on mood and the ability to use devices "on the go" were valued (Dennison et al., 2013).

Present study

Mindfulness research has been based primarily on the MBSR and MBCT's 8-week intensive programme which is impractical for students (Jain et al., 2007) therefore; the present study aimed to investigate mobile-based mindfulness as a shorter and more accessible intervention. Past research into MBMA's are largely unexplored and have only assessed ratings of applications (Mani et al., 2015) or have not used a control group (Plaza et al., 2013) therefore this study will investigate the highest-level rating application 'Headspace' using an effective control group. This study examined whether mobile-based mindfulness has a positive effect on psychological well-being between self-reported trait-mindfulness, anxiety, depression and rumination in a student population. Research into the minimal duration required for mindfulness is unclear (Zeidan et al., 2010), therefore the current study assessed the efficiency of ten-minutes a day of ten-day's practice. Such mindfulness research has been inadequate by not comparing experimental conditions to active controls therefore, the proposed study used a pre-test to post-test experimental design and participants were randomly assigned to either a mindfulness condition or active control condition.

Research hypotheses

It was firstly hypothesised that from pre-test to post-test mindfulness intervention, participants would report a significant increase in trait mindfulness. Secondly, it was hypothesised that the mindfulness condition would report a significant decrease in self-reported anxiety from pre-intervention to post-intervention. Thirdly, it was hypothesised that the mindfulness condition will reduce self-reported levels of depression from pre-intervention to post-intervention and fourthly hypothesised that the mindfulness condition self-reported rumination will also decrease after intervention. In the control condition, no significant changes are expected in any of the variables from pre-intervention to post-intervention.

Method

Design

A 2 X 2 mixed experimental design was used where the between-subject's independent variable (IV) was group type (mindfulness vs. control) and the within-subjects IV was assessment time (pre-intervention vs. post-intervention). The dependent variables (DV) were self-reported trait mindfulness, anxiety, depression and rumination scores. The study used a pre-test, post-test experimental design as self-reported questionnaires were completed prior to and following a short intervention.

Participants

Participants were recruited using an opportunity sample from the target population of students through the universities participation pool. Advertisements specified eligible participants needed to be a student, over the age of 18 and have access to a smartphone.

A power analysis (Appendix 11) calculated using G* power, 3.1.3 (Faul et al., 2007) determined that a minimum of 36 participants were needed[1]. A total of 40 participants took part, (n = 20) for the mindfulness condition and (n = 20) for the controlled condition, with an age range of 18-40 (Median age group = 18-24) and consisted of males (50%) and females (50%). Participants were matched for age and gender before being randomly assigned to a condition, allowing 10 females and 10 males in each condition. Responses indicated that the study was predominately employed of (82.5%) undergraduate-level students and (17.5%) postgraduate-level students. Participants were not matched for scores on the self-reported scales before being assigned to a condition as it would not be possible to indicate that participants had similar levels of all four factors which had been followed by Howells et al. 2016.

Materials

Self-report Questionnaires (Appendices 8-10)

The study used a range of questionnaires with established reliability and validity to measure dimensions of psychological well-being at baseline. The same questionnaires were presented post-intervention to capture levels of psychological well-being improving.

The Mindfulness Attention Awareness Scale (MAAS; Brown and Ryan, 2003), trait version, is a 15 item self-report scale designed to measure core characteristics of mindfulness. Item response is rated on a 6-point Likert-scale (1 = almost always, to 6 = almost never). High score totals represents higher levels of mindfulness, the highest score being 90 and the lowest score is 0. The MAAS has demonstrated good overall consistency level with a Cronbach's alpha ranging from .80 to .90 (Brown and Ryan, 2003).

The Depression Anxiety Stress Scale (DASS; Lovibond and Lovibond, 1995) is a 42 item self-report measure of anxiety, depression and stress and comprises three subscales. For the purpose of this research, depression and anxiety scales were used therefore, consisted of 14 items for depression and 14 items for anxiety, where the highest score is 42 and the lowest score is 0 for each scale. This is acceptable according to the authors instructions and item response is rated on a 4-point Likert-scale (0= did not apply to me, to 3 = applies very much). Higher scores represent higher levels of depression and anxiety and each scale has good internal consistency with a Cronbach's alpha of .96 for depression and .92 for anxiety (Page et al., 2007).

The Rumination Reflection Questionnaire (RRQ; Trapnell and Campell, 1999) is an operationalised reflection form of self-focused thoughts consisting of 12 items. Item response is rated on a 5-point Likert-scales (1 = strongly disagree, to 5 = strongly agree). Higher scores represent higher level of rumination, the highest score being 60 and the lowest score is 0. The rumination subscale of the RRQ displayed good internal consistency with a Cronbach's alpha of .90 (Trapnell and Campbell, 1999).

All scales are in the public domain and free from copyright.

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[1] Calculated using a significance level of .05, power of .8, and a small effect size (Cohen's d = 0.25).

Interventions and Podcasts

The mindfulness condition engaged with an empirically based intervention and listened to Headspace-On-The-Go (Puddicombe, 2013) which consists of recordings of basic mindfulness practices of simple guided meditations and is supported by science (Howells et al., 2016). Participants followed daily mindfulness exercises on the 'take 10' program for 10 minutes a day over 10 days. Headspace "take 10" involves audio-guided mindfulness techniques which includes an introduction to mindfulness meditation, breathing and emotions exercise's. The recordings also incorporate essential aspects of the MBSR such as sitting meditation and the body scan and Headspace is representative of other mindfulness interventions who use voice recorded files to develop mindfulness attention and awareness (Kabat-Zinn, 1982). This brief and easy application is free to download and permission was obtained prior to the study to use Headspace for experimental purposes (Appendix 12).

Participants in the control condition watched podcast videos on the Technology, Entertainment and Design (TED; Anderson, 2005) application. TED is a series of conference videos and events created to provide an opportunity for ideas to be shared. Participants watched one TED talk, varying between 8-11 minutes each day for 10 days. The consistency of the talks varied from 'ten ways to have a better conversation' to 'four reasons to learn a new language'. TED was chosen for the control condition, as it is a similar format to the experimental intervention; therefore participants had a similar experience in time and activity level. Also, using educational film clips has been validated to be used with mindfulness conditions (Erisman and Roemar, 2010).

Overall, the mindfulness and control condition recordings equated to the same length of time. Accordingly, participants in both conditions underwent approximately 100 minutes of intervention over the 10-day period.

Procedure

Participants were assigned to a mindfulness condition or control condition and both interventions lasted 10 days. Firstly, participants were distributed instructions according to the participants assigned condition (Appendix 13). This included a website link for participants to complete the MAAS, DASS and RRQ questionnaires prior to the intervention. Demographic information was collected before baseline psychological measures were done. Participants were then advised to follow instructions on how to download the appropriate application to a smartphone device.

Participants in the mindfulness condition were advised to download and follow Headspace's "take 10" programme which consisted of 10 day's mindfulness exercise's through recordings. A manipulation check was used to ensure participants took part in the intervention. Participants signed up to the applications buddy system, allowing the researcher to monitor participant statistics and remind them to meditate. Participants in the control condition watched one TED talk, as advised by the researcher, for 10 days. A manipulation check was used as participants were asked to answer two questions based on the video they watched that day. This allowed the researcher to ensure that participants were taking part in watching the videos.

To ensure changes were attributed to the mindfulness intervention the control condition followed a similar format. The interventions were of the same intensity,

format and both conditions were advised to do the interventions in a seated position in a natural and calm environment. After the 10 days, a follow-up email was sent to prompt participants to complete the study's questionnaire, following the instruction sheet which was the same questionnaires outlined on day 1.

Baseline measurements of all variables (mindfulness, anxiety, depression and rumination) were assessed at pre-intervention[2] and again at post-intervention[3].

Participants completed the study in their natural environment's which has greater ecological validity as it is more natural to the participant (Hartig et al., 1991). Correspondingly, there was no face-to-face contact between the researcher and participants during the whole study. This ensured there was no experimenter bias and demand characteristics which could influence participants results (Nichols and Maner, 2008).

Ethics

Ethical issues were considered and BPS guidelines were followed in accordance to the 'Codes of Ethics and Conduct' (Appendices 1-3). Informed consent (Appendix 6) was obtained prior to the onset of the study. Participants were given information sheets (Appendix 5) and debriefed at the end of the study (Appendix 7) which differed for each condition. One major ethical issue was that the mindfulness condition was receiving a beneficial intervention aimed at improving psychological well-being and the control condition were asked to contribute the same amount of time yet did not receive any positive changes. However, the control videos were deliberately selected due to the interesting and informative content. At debrief, participants in the control condition were given information about mindfulness and instructions to download the Headspace application.

Results

Preparation of data

All raw data from the mindfulness (n = 20) and control (n = 20) conditions were entered into IBM SPSS statistics 23.0 to be analysed; all data output can be found in Appendices 14-20. Following data input from all questionnaires, the appropriate items in the RRQ were reverse scored, in line with the author's instructions as detailed in the materials section, and total scores for each questionnaire at each assessment time (pre-intervention and post-intervention) were calculated.

To check internal consistency reliability, Cronbach's alpha (α) coefficients were generated for all scales at each assessment time. The majority of measures at each assessment time had an α coefficient significantly above .70, However, MAAS at pre-intervention and the RRQ at pre-intervention and post-intervention was not significant as shown in Table 1, which is accepted as representing satisfactory reliability (Nunally, 1978).

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[2] Pre-intervention reflects scores at Day 1.

[3] Post-intervention reflects scores at Day 10.

Table 1

Internal Consistency and Confidence Intervals for All Measures at Each Assessment Time for (N = 40)

MAAS = Mindfulness Attention Awareness Scale, DASS = Depression Anxiety and Stress Scale, RRQ = Rumination Reflection Questionnaire.

Measures	Number of items	Cronbach's alpha	95% Confidence Interval for alpha	
			Lower	Upper
MAAS				
Pre-intervention	15	.71	.56	.83
Post-intervention	15	.85***	.78	.91
DASS (Anxiety)				
Pre-intervention	14	.94***	.90	.96
Post-intervention	14	.94***	.92	.97
DASS (Depression)				
Pre-intervention	14	.96***	.93	.97
Post-intervention	14	.97***	.96	.98
RRQ				
Pre-intervention	12	.75	.62	.85
Post-intervention	12	.77	.65	.86

Note: F test with true value = .7, * $p < .05$. **$p < .01$. ***$p < .001$

Hypothesis one

To determine whether trait mindfulness scores had significantly increased from pre-intervention to post-intervention, MAAS scores were measured pre-post intervention in both conditions. Table 2 provides the means (M) and standard deviations (SD) for the MAAS for both mindfulness and control conditions at pre-intervention and post-intervention.

Table 2

Descriptive Statistics for the MAAS at Pre-intervention and Post-intervention

Participant Condition						
	Mindfulness (n = 20)		Control (n = 20)		All (N = 40)	
Assessment Time	M	SD	M	SD	M	SD
MAAS Pre-intervention	46.75	10.56	54.75	9.19	50.75	10.58
MAAS Post-intervention	69.25	6.42	50.85	10.63	60.05	12.73

A 2 X 2 mixed factorial ANOVA[4] was conducted, where the within-subject's independent variable was assessment time (pre-intervention and post-intervention), the between-subject's independent variable was condition (mindfulness or control) and the dependent variable was the mindfulness score[5]. A significant main effect for assessment time was found, $F(1, 38) = 26.89$, $p < .001$, $\eta p^2 = .414$ and for condition $F(1, 38) = 4.88$, $p = .033$, $\eta p^2 = .114$. A significant interaction was found between assessment time and condition, $F(1, 38) = 54.17$, $p < .001$, $\eta p^2 = .588$. Figure 1 illustrates this interaction.

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[4] ANOVA (analysis for variance)

[5] All significance values reported are two-tailed with an alpha level of .05 unless otherwise stated.
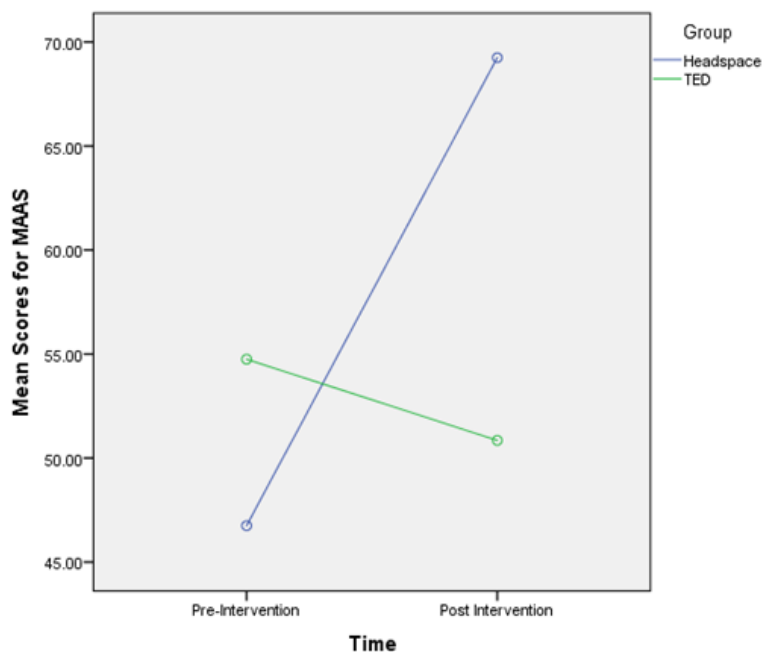
Figure 1. A plot to illustrate the interaction between condition (mindfulness or control) and assessment time (pre-intervention and post-intervention) for the MAAS.

Post Hoc Analyses

To further interpret the significance interaction between condition and time on mindfulness scores, two paired samples t-tests and two independent t-tests were conducted.[6]

Two separate paired sample t-tests were performed on the mindfulness and control conditions. The independent variable was assessment time (pre-intervention and post-intervention) and the dependent variable was mindfulness scores. A significant increase in mindfulness scores was found for the mindfulness condition from pre-intervention (M = 46.75, SD = 10.56) to post-intervention (M = 69.25, SD = 6.42), t(19) = 6.92, p < .001, d[7] = 2.51, 95% CI [1.53 – 3.49]. No significant difference was found between MAAS scores for the control condition from pre-intervention (M = 54.75, SD = 9.19) to post-intervention (M = 50.85, SD = 10.63), t(19) = 2.57, d = 0.38, 95% CI [0.06 – 0.70].

The first independent t-test was conducted on MAAS scores pre-intervention where the independent variable was condition (mindfulness or control) and the dependent variable was mindfulness scores. Mindfulness scores were not significantly different between the mindfulness (M = 46.75, SD = 10.56) and the control condition (M = 54.75, SD = 9.19) at pre-intervention, t(38) = 2.56, p = .015. d = 0.79. 95% CI [0.14 – 1.44]. The second independent t-test was conducted on mindfulness scores post-intervention where the independent variable was mindfulness scores. Mindfulness

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[6] A Bonferroni correction was used for all independent and paired samples t-tests to reduce the chance of family wise error (.05/4) producing a new alpha reliability level of .0125

[7] All effect size interpretations are based on Cohen's 1988 conventions for values of adjusted d where small effect size = .25, medium effect size =.50 and large effect size = .80.

scores were significantly higher for the mindfulness condition (M = 69.25, SD = 6.42) compared to control condition (M = 50.85, SD = 10.63) at post-intervention, t(38) = 6.62, p < .001, d = 2.05, 95% CI [1.25 – 2.86]. This indicates that only the mindfulness condition experienced a significant increase from pre-to post intervention with no changes in the control condition.

Hypothesis two

To determine whether anxiety scores had significantly increased from pre-intervention to post-intervention, DASS anxiety scores were measured pre-post intervention in both conditions. Table 2 provides the means and standard deviations for the DASS (anxiety) for both mindfulness and control conditions at pre-intervention and post-intervention.

Table 3

Descriptive Statistics for the DASS Anxiety at Pre-intervention and Post-intervention

Participant Condition						
	Mindfulness (n = 20)		Control (n = 20)		All (N = 40)	
Assessment Time	M	SD	M	SD	M	SD
DASS Anxiety Pre-intervention	28.65	10.47	23.20	6.82	25.92	9.15
DASS Anxiety Post-intervention	16.80	2.28	25.00	8.53	20.90	7.43

A 2 X 2 mixed factorial ANOVA was conducted, where the within-subject's independent variable was assessment time (pre-intervention and post-intervention), the between-subject's independent variable was condition (mindfulness or control) and the dependent variable was the anxiety score. A significant main effect for assessment time was found, $F(1, 38) = 16.77$, $p < .001$, $\eta p^2 = .306$ and for condition $F(1, 38) = .43$, $p = .514$, $\eta p^2 = .011$. A significant interaction was found between assessment time and condition, $F(1, 38) = 30.95$, $p < .001$, $\eta p^2 = .449$. Figure 2 illustrates this interaction.
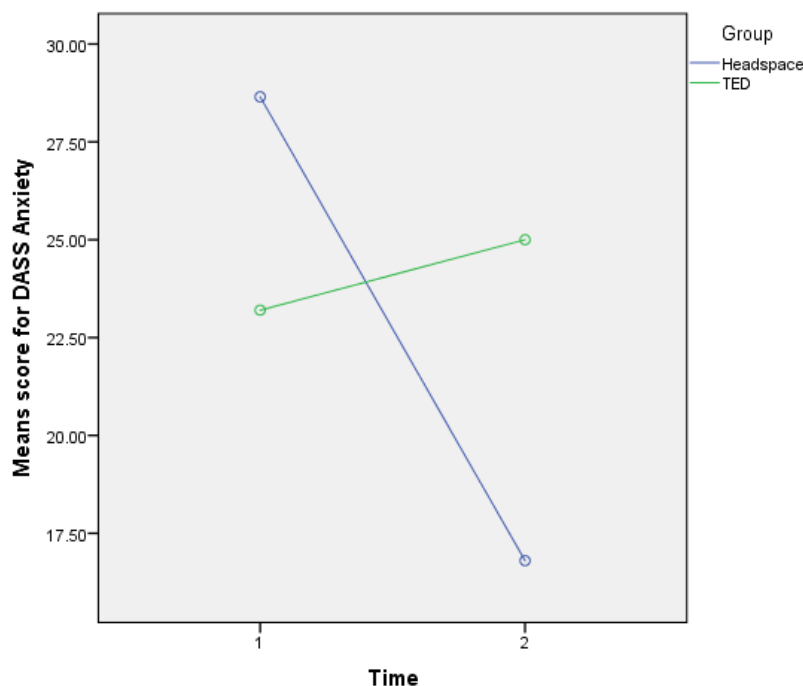
Figure 2. A plot to illustrate the interaction between condition (mindfulness or control) and assessment time (pre-intention and post-intervention) for the anxiety scores.

Post Hoc Analyses

To further interpret the significance interaction between anxiety scores, two paired samples t-tests and two independent t-tests were conducted.

Two separate paired sample t-tests were performed on the mindfulness and control conditions. The independent variable was assessment time (pre-intervention and post-intervention) and the dependent variable was anxiety scores. A significant decrease in anxiety scores was found for the mindfulness condition from pre-intervention (M = 28.65, SD = 10.47) to post-intervention (M = 16.80, SD = 2.28), $t(19) = 5.30$, $p < .001$, $d = 1.52$, 95% CI [0.78 – 2.26]. No significant difference was found between anxiety scores for the control condition from pre-intervention (M= 23.20, SD = 6.82) to post-intervention (M = 25.00, SD = 8.53), $t(19) = 1.78$, $p = .091$, $d = 0.23$, 95% CI [-0.04 – 0.49].

The first independent t-test was conducted on anxiety scores pre-intervention where the independent variable was condition (mindfulness or control) and the dependent variable was anxiety scores. DASS anxiety scores were not significantly different between the mindfulness (M = 28.65, SD = 10.47) and the control condition (M = 23.20, SD = 6.82) at pre-intervention, $t(38) = 1.95$, $p = .058$, $d = 0.60$, 95% CI [-0.04 – 1.24]. The second independent t-test was conducted on anxiety scores post-intervention where the independent variable was anxiety scores. Anxiety scores were significantly lower for the mindfulness condition (M = 16.80, SD = 2.28) compared to control condition (M = 25.00, SD = 8.53) at post-intervention, $t(38) = 4.15$, $p < .001$, $d = 1.29$, 95% CI [0.56 – 2.02]. This indicates that only the mindfulness condition experienced a significant decrease in anxiety from pre-to post intervention and there were no changes in the control condition.

Hypothesis Three

To determine whether depression scores had significantly decreased from pre-intervention to post-intervention, depression scores were measured pre-post intervention in both conditions. Table 2 provides the means and standard deviations for the DASS (depression) for both mindfulness and control conditions at pre-intervention and post-intervention.

Table 3

Descriptive Statistics for the DASS Depression at Pre-intervention and Post-intervention

Participant Condition						
	Mindfulness (n = 20)		Control (n = 20)		All (N = 40)	
Assessment Time	M	SD	M	SD	M	SD
DASS Depression Pre-intervention	30.85	12.08	27.35	7.49	29.10	10.08
DASS Depression Post-intervention	17.35	3.73	28.40	10.36	22.87	9.51

A 2 X 2 mixed factorial ANOVA was conducted, where the within-subject's independent variable was assessment time (pre-intervention and post-intervention), the between-subject's independent variable was condition (mindfulness or control) and the dependent variable was the depression score. A significant main effect for assessment time was found, $F = (1, 38) = 21.79$, $p < .001$, $\eta p^2 = .365$ and for condition $F(1, 38) = 2.26$, $p = .141$, $\eta p^2 = .056$. A significant interaction was found between assessment time and condition, $F(1, 38) = 29.77$, $p < .001$, $\eta p^2 = .439$.

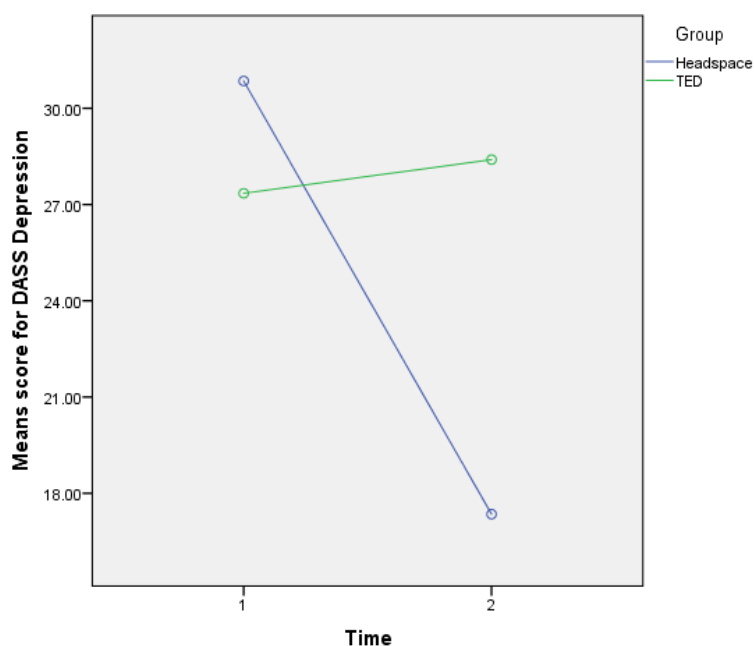Figure 3 illustrates this interaction.

Figure 3. A plot to illustrate the interaction between condition (mindfulness or control) and assessment time (pre-intervention and post-intervention) for the depression scores.

Post Hoc Analyses

To further interpret the significance interaction between condition and time on depression scores, two paired samples t-tests and two independent t-tests were conducted.

Two separate paired sample t-tests were performed on the mindfulness and control conditions. The independent variable was assessment time (pre-intervention and post-intervention) and the dependent variable was depression scores. A significant decrease in depression scores was found for the mindfulness condition from pre-intervention (M = 30.85, SD = 12.08) to post-intervention (M = 17.35, SD = 3.73), t(19) = 5.49, p < .001, d =. 1.47, 95% CI [0.78 – 2.16]. No significant difference was found between depression scores for the control condition from pre-intervention (M = 27.35, SD = 7.49) to post-intervention (M = 28.40, SD = 10.36), t(19) = .1.02, p = .32 ,d = 0.11, 95% CI [-0.11 – 0.34].

The first independent t-test was conducted on the depression scores pre-intervention (where the independent variable was condition (mindfulness or control) and the dependent variable was depression scores. Depression scores were significantly different between the mindfulness (M = 30.85, SD = 12.08) and the control condition (M = 27.35, SD = 7.49) at pre-intervention, t(38) = 1.10, p = .001, d = 0.34, 95% CI [-0.29 – 0.97]. The second independent t-test was conducted on depression scores post-intervention where the independent variable was depression scores. Depression scores were significantly lower for the mindfulness condition (M = 17.35, SD = 3.73) compared to control condition (M = 28.40, SD = 10.36) at post-intervention, t(38) = 4.49, p < .001, d = 1.39, 95% CI [0.65 – 2.13]. This indicates that

only the mindfulness condition experienced a significant decrease in depression from pre-to post intervention and there were no changes in the control condition.

Hypothesis Four

To determine whether rumination scores had significantly decreased from pre-intervention to post-intervention, RRQ scores were measured pre-post intervention in both conditions. Table 2 provides the means and standard deviations for the RRQ for both mindfulness and control conditions at pre-intervention and post-intervention.

Table 4

Descriptive Statistics for the RRQ at Pre-intervention and Post-intervention

Participant Condition						
	Mindfulness (n = 20)		Control (n = 20)		All (N = 40)	
Assessment Time	M	SD	M	SD	M	SD
RRQ Pre-intervention	47.05	8.18	42.40	4.83	44.72	7.04
RRQ Post-intervention	31.80	6.51	42.25	7.57	37.02	8.75

A 2 X 2 mixed factorial ANOVA was conducted, where the within-subject's independent variable was assessment time (pre-intervention and post-intervention), the between-subject's independent variable was condition (mindfulness or control) and the dependent variable was the RRQ (rumination) score. A significant main effect for assessment time was found, $F(1, 38) = 37.42$, $p < .001$, $\eta p^2 =. 496$ and for condition $F(1, 38) = 2.66$, $p = .111$, $\eta p^2 = .065$. A significant interaction was found between assessment time and condition, $F(1, 38) = 35.98$, $p < .001$, $\eta p^2 = .486$. Figure 4 illustrates this interaction.
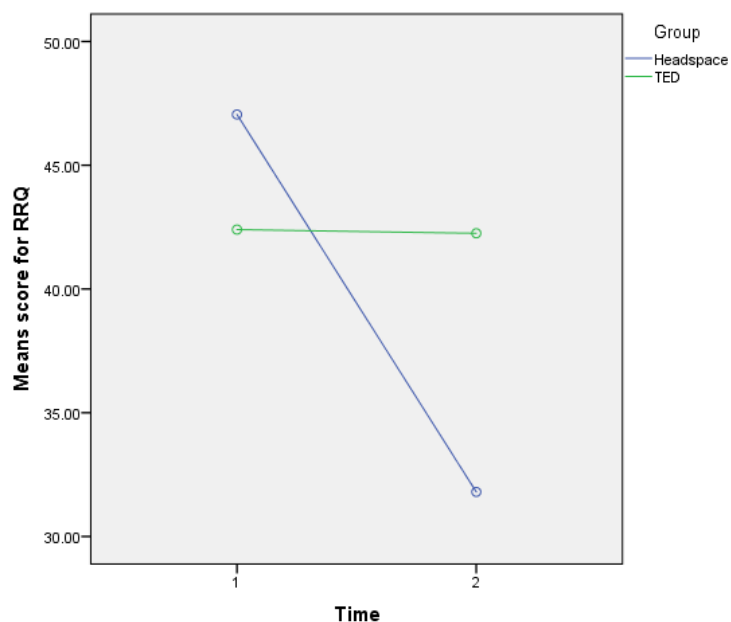
Figure 4. A plot to illustrate the interaction between condition (mindfulness or control) and assessment time (pre-intervention and post-intervention) for RRQ.

Post Hoc Analyses

To further interpret the significance interaction between condition and time on rumination scores, two paired samples t-tests and two independent t-tests were conducted.

Two separate paired sample t-tests were performed on the mindfulness and control conditions. The independent variable was assessment time (pre-intervention and post-intervention) and the dependent variable was rumination scores. A significant decrease in rumination scores was found for the mindfulness condition from pre-intervention (M = 47.05, SD = 8.18) to post-intervention (M = 31.80, SD = 6.51), t(19) = 7.03, p < .001, d = 2.01, 95% CI [1.27 – 2.75]. No significant difference was found between rumination scores for the control condition from pre-intervention (M = 42.40, SD = 4.83) to post-intervention (M = 42.25, SD = 7.57), t(19) = .117, p = .908, d = 0.02, 95% CI [- 0.37 – 0.42].

The first independent t-test was conducted on rumination scores pre-intervention where the independent variable was condition (mindfulness or control) and the dependent variable was rumination scores. Rumination scores were not significantly different between the mindfulness (M = 47.05, SD = 8.18) and the control condition (M = 42.40, SD = 4.83) at pre-intervention, t(38) = 2.18, p = .035, d = 0.68, 95% CI [0.03 – 1.32]. The second independent t-test was conducted on rumination scores post-intervention where the independent variable was rumination scores. Rumination scores were significantly lower for the mindfulness condition (M = 31.80, SD = 6.51) compared to control condition (M = 42.25, SD = 7.57) at post-intervention, t(38) = 4.68, p < .001, d = 1.45, 95% CI [0.75 – 2.16]. This indicates that only the mindfulness condition experienced a significant decrease in rumination from pre-to post intervention and there were no changes in the control condition.

Discussion

The current study aimed to measure the effects of a brief mindfulness-based intervention on trait mindfulness, anxiety, depression and rumination as compared to an active control group. All results observed supported all four hypotheses.

Hypothesis One: Mindfulness

As hypothesised, it was found that trait mindfulness as measured by the MAAS significantly increased from pre-post intervention in the mindfulness condition but not in the control condition. These results support Howells et al. (2016) who suggest that MBMA's using effective mindfulness practice will increase self-reported trait mindfulness. Teasdale et al. (2000) found that with an eight-week face-to-face MBCT intervention trait mindfulness significantly increases. However, the current study suggests that a mindfulness intervention as short as ten days and through a mobile application significantly increases trait mindfulness. The incorporated buddy system in the Headspace application ensured participants were participating with the mindfulness practices. Therefore, it is suitable to propose that the increase in trait mindfulness established within the mindfulness condition is attributed to the mindfulness-based intervention.

Hypothesis Two: Anxiety

As hypothesised, it was found that self-reported anxiety, as measured by the DASS, significantly decreased in the mindfulness condition from pre-post intervention but not in the control condition. This finding supports the research that has found mindfulness to be effective at improving anxiety levels (Hofmann et al., 2010; Finucane and Mercer, 2006). This also supports the use of a short mindfulness intervention to improve psychological well-being. Those using MBSR interventions withstand intensive eight week programs, which may be impractical and too long for students (Champion and Rocco, 2009; Mapel, 2012), therefore a brief intervention may prove useful. This finding supports Shapiro et al. (1998) suggestion in that mindfulness may be potentially useful resource for reducing anxiety for students.

Hypothesis Three: Depression

As hypothesised, it was found that self-reported depression levels, as measured by the DASS significantly decreased in the mindfulness condition from pre-post intervention, but not for the control condition. Contrastingly from research (Shapiro et al., 2005), the current study used an active control condition to ensure a significant interaction was found between mindfulness and depression. Therefore, this present study further supports the role of mindfulness for depression as found with previous research (Ma and Teasdale, 2004).

Hypothesis Four: Rumination

Supporting the final hypothesis, it was found that self-reported rumination levels, as measured by the RRQ significantly decreased in the mindfulness condition from pre-post intervention but not for the control condition. This supported Jain et al. 2007 who discovered that self-reported rumination can decrease with mindfulness interventions in a student population. These results are also in line with the Response Styles Theory who suggest mindfulness has a positive impact on rumination styles. Therefore, the decrease of rumination is found with increased mindfulness (Nolen-Hoeksema, 2004). The current study offers important theoretical

implications as the findings support existing literature regarding the relationship between mindfulness and rumination (Gaynor, 2014; Deyo et al., 2009).

Strengths and Limitations

The main strength of this study includes random allocation of study participation to intervention conditions and applying an active control condition with a similar procedure to the mindfulness condition. It is appropriate to suggest that the significant changes in mindfulness were due to the mindfulness-based intervention, as the control group completed activities that were unrelated to mindfulness for the same amount of time as the mindfulness condition. However, there are several issues to address before conducting future short-term interventions.

Firstly, the current study did employ an active control condition, however future research should compare mindfulness interventions that are similarly designed to increase psychological well-being such as Jain et al. (2007). Comparing mindfulness to similar practices, for example relaxation techniques, outcomes would be able to be identified, serving clarification that mindfulness was operationalised to the change (Brown and Ryan, 2003).

Furthermore, this study is restricted to the reliance of self-report measures. While practically most mindfulness research uses self-report measurements, it is challenging to measure the precision of participant's responses and limitations require to the possibility of social desirability and response biases (Brown and Ryan, 2003). To increase validity, future studies may benefit by using different measures such as assessing structural and functional neuroimaging to measure neurobiological mechanisms such as Tang et al. 2015. Also, qualitative methods, such as interviews, have been successful at measuring mindfulness (Finucane and Mercer, 2006).

Moreover, the absence of face-to-face interaction and using mobile applications may produce methodological limitations including participant distraction, lack of concentration and interest, low battery problems, or low internet connection which is not controlled by such study. However, it is likely that innovative ways to overcome these issues may be developed as MBMA research grows (Howells et al., 2016).

Furthermore, the format of interventions could have been altered to maximise the positive impact of mindfulness training. In traditional MBSR interventions they have a group facilitator that conducts the sessions which may be more beneficial to induce mindfulness. However, podcast recordings are a very accessible way for students to engage with mindfulness and offers a simple, low cost way for individuals to practice mindfulness in their own environment. However, this study used existing mobile applications, as the researcher did not create the design of the intervention. Also, the accessible content determined the duration of the study and limited the study to ten days. For future, it would be ideal for the researcher to create the intervention (Howells et al., 2016).

Implications

Further, the present study indicates that a mobile-based mindfulness intervention is effective in generating a significant increase in trait mindfulness, which is consistent with research (Howells et al. 2016). Due to increasing reports of student mental health problems (Andrew and Wilding, 2004) it is imperative for accessible mindfulness-based interventions for students to be explored therefore the present findings are promising in terms of the contribution of brief mindfulness-based interventions on the psychological well-being of students.

Although there has been significant research for the effectiveness of MBI's, research is needed in investigating the effectiveness of MBMA's and the minimum of duration necessary for interventions to improve psychological well-being. The current study offers a practical substitute to traditional mindfulness interventions for improving trait mindfulness and reducing anxiety, depression and rumination for students following a brief intervention that is a ten-minute activity over a ten-day period.

Furthermore, universities could benefit from applying this intervention and subscribing students to MBMA's as this intervention has showed to improve psychological well-being of students. The number of reported students suffering from mental health problems may decrease by the beneficial impact this intervention has demonstrated. However, the understanding of positive effects of whether this intervention is long-term requires further study and a follow-up procedure.

Conclusion

The present study determines that a brief (10 day), low-cost and more accessible mindfulness intervention, compared to an active control condition, was successful in significantly increasing levels of trait mindfulness and decreasing levels of anxiety, depression and rumination, which may be of use to the psychological well-being of student populations. This research determines the minimum duration and quality required for MBI's to improve psychological well-being and may prove useful for students and universities. In summary, the findings demonstrate the positive effects for students to utilise such interventions in order to improve psychological well-being that is demonstrated across the literature.

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