Effects of length of mindfulness practice on mindfulness, depression, anxiety and stress: a randomized controlled experiment

Strohmaier, S., Jones, F. and Cane, J.

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a randomized controlled experiment

Sarah Strohmaier [a], Fergal W. Jones [b], James E. Cane [c]

[a,b,c] Canterbury Christ Church University, United Kingdom

Corresponding author: Sarah Strohmaier, Salomons Institute for Applied Psychology,

Canterbury Christ Church University, Tunbridge Wells TN1 2YG, United Kingdom;

Tel: +44 (0)1227 92 7092; Email: sarah.strohmaier@canterbury.ac.uk

[a]ORCID iD: 0000-0002-2569-8447

[b]ORCID iD: 0000-0001-9459-6631

[c]ORCID iD: 0000-0003-3849-562X

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informed consent.

Abstract

Objectives: Mindfulness-based programs (MBPs) vary in length of mindfulness practices included. It might be expected that longer practice leads to greater benefits in terms of increased mindfulness and decreased psychological distress. However, the evidence for such dose-response effects is mixed and generally does not support such strong causal conclusions given its correlational nature. Therefore, the current study sought to clarify which length of mindfulness practice led to greater benefits using an experimental design.

Methods: Participants ($N = 71$; 71.8% female), who were healthy adults with limited prior mindfulness practice experience, were randomized to either (i) four longer (20-minute) mindfulness practices, (ii) four shorter (5-minute) mindfulness practices or (iii) an audiobook control group. All sessions were held in-person over a two-week period, each group listened to the same total length of material each session, and participants refrained from formal mindfulness practice outside of sessions.

Results: Both longer and shorter practice significantly improved trait mindfulness, depression, anxiety, and stress compared to controls. Unexpectedly, shorter practice had a significantly greater effect on trait mindfulness ($d = 2.17$; $p < .001$) and stress ($d = -1.18$; $p < .01$) than longer practice, with a trend in the same direction for depression and anxiety. Mediation analysis findings were mixed.

Conclusions: Even a relatively small amount of mindfulness practice can be beneficial and shorter practices may initially be more helpful for novice practitioners in MBPs with minimal teacher contact. Further research is needed to examine such dose-response effects when teacher involvement is greater and over the longer term.

Keywords*: mindfulness; mindfulness-based programs; mindfulness practice length; depression; anxiety; stress*

In recent years, there has been a rapid growth in mindfulness-based programs (MBPs) and research around their use and effectiveness (Goldberg et al. 2018). Formal mindfulness practice forms a central feature of such programs and they are arguably predicated on an assumption that practicing mindfulness leads to an increase in trait and state mindfulness, which in turn improves wellbeing (Crane et al. 2017). Consistent with this, MBPs have been found to increase mindfulness and to have beneficial effects on a range of outcomes, including depression, stress, anxiety, and wellbeing (e.g. Goldberg et al. 2018; Strohmaier 2020). Furthermore, there is evidence that changes in mindfulness statistically mediate changes in at least some of these outcomes, though (as with any psychosocial program) MBPs very likely have other active ingredients also, e.g. rumination and worry (Gu et al. 2015; Kiken et al. 2015).

While MBPs all emphasize the importance of mindfulness practice, there is considerable variability in their mode of delivery, from self-help apps and books to in-person, teacher-led groups, and there are substantial differences in the length of mindfulness practice that MBPs teach and recommend for homework (Strohmaier 2020). For example, in Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT) participants are asked to practice mindfulness almost daily, at home, for up to an hour (Kabat-Zinn 1990; Segal et al. 2013). By way of contrast, an increasing number of MBPs are delivered online or via apps; these often involve shorter practices (e.g. Bostock et al. 2018; Spijkerman et al. 2016). This raises important questions about whether there is an optimal length of mindfulness practice and whether the effectiveness of different practice may depend on participant group.

It can be inferred from a number of theories that, in general, longer and a greater overall amount of practice are believed to be more beneficial (e.g. Beattie et al. 2019; Shapiro et al. 2006; Teasdale 1999). For instance, according to mode of mind theory, individuals need

to engage in continued mindfulness practice to be able to switch from a "doing" mode of mind, to a "being" mode of mind, in order to improve trait and state mindfulness. This subsequently results in disengagement from rumination and more positive mental health outcomes (Segal et al. 2013; Williams 2008). In a similar vein, Kabat-Zinn (1990) has argued that it can be helpful to think of mindfulness as a muscle that needs to be exercised through continuous practice. Thus, on the basis of theory, it seems reasonable to expect a dose-response relationship between length and overall amount of mindfulness practice and beneficial outcomes.

Some evidence for such a relationship has been found. For example, in a meta-analysis of MBSR and MBCT studies, the amount of participants' self-reported formal mindfulness practice significantly correlated with positive outcomes, albeit with a small effect size (Parsons et al. 2017). Similarly, Greenberg et al. (2018) has found a high dose of home practice during an MBP to be associated with reduced stress in adults, whereas a low dose was not. Furthermore, lower levels of anxiety and a significant reduction in experiences of unpleasantness have been observed in long-term meditators compared to novices (Desbordes et al. 2015). Additionally, higher frequency of formal mindfulness practice has been found to relate to increased wellbeing in participants with varying levels of mindfulness practice experience (Birtwell et al. 2019). However, in a recent dose-response meta-regression, which considered a range of different dose variables across 203 randomized controlled trials of MBPs for adults, the findings were more mixed (Strohmaier 2020). For example, greater actual use of an MBP, including mindfulness practices, was found to predict increased mindfulness post-program, but no robust dose-response relationships were found for psychological distress outcomes. Strohmaier (2020) has detailed a number of possible limitations that may have contributed to this mixed picture, including: (i) memory and social desirability biases leading to inaccuracies in the measurement of home practice; (ii) difficulty

determining the extent to which participants were actually practicing mindfulness; and (iii) the possibility that dose-response effects may have been different for different participant groups (e.g. novice vs. more experienced practitioners). Mixed findings regarding practice length have also been observed in research with adolescents, with greater amounts of home practice being associated with positive outcomes in some studies (e.g. Huppert and Johnson 2010; Kuyken et al. 2013), but not in others (e.g. Johnson et al. 2016; Quach et al. 2017). Other research in schools has shown a more mixed pattern of findings within the same study (e.g. Volanen et al. 2020).

Especially for novices, longer practices have been described as problematic and confusing (Desbordes et al. 2015), with novice practitioners tending to be more susceptible to mind-wandering during longer practices, in particular when feeling stressed (cf. Crosswell et al. 2020; Frewen et al. 2016). In addition, qualitative research has suggested that longer mindfulness practices can be viewed by participants as particularly challenging and have been cited as the reason to discontinue practice (Banerjee et al. 2017). These difficulties for novices to engage in longer practices may also be reflected in the relatively high levels of attrition from longer MBPs such as MBSR and MBCT, as well as discontinuing practice after commencement of a program (Dobkin et al. 2011).

In part to address the challenges of longer mindfulness programs and practices, and to increase the accessibility of and engagement with MBPs, in recent years there has been an increase in research with lower-dose MBPs, which has usually included shorter practices (Spijkerman et al. 2016).These programs can be delivered face-to-face, but are also increasingly offered through self-help applications, including via apps and online websites (Jones et al. 2016). For instance, in a previous review of online MBPs, which usually included briefer daily mindfulness practices, it has been discovered that these programs were associated with beneficial outcomes on participants' levels of mindfulness and psychological

distress (Spijkerman et al. 2016). Furthermore, in a recent randomized controlled trial of 200 university students comparing an active control with different mindfulness apps (Headspace, Smiling Mind), where participants were asked to practice mindfulness for 10 minutes a day for 10 days, a significant increase in mindfulness as well as significant positive effects on depression, adjustment to university and resilience were found (Flett et al. 2019). Therefore, beneficial effects have been identified for MBPs containing longer as well as shorter mindfulness practices, including increased levels of mindfulness and decreasing psychological distress.

However, a limitation of previous research is that amount of mindfulness practice that participants have engaged in over the course of an MBP was often either not measured at all or not measured accurately enough (Vettese et al. 2009). This is particularly the case for practices completed outside of teacher-led sessions. For instance, in a previous review, only a small number of studies had examined the effects of home practices and this was not assessed in a controlled way (Lloyd et al. 2018). Furthermore, a recent MBP with novice practitioners examining adherence to mindfulness practice found that changes in self-report measures of mindfulness, quality of life, depression and stress were not significantly associated with time spent practicing (Ribeiro et al. 2018). Reliable conclusions on the actual observed effects of longer versus shorter practices can arguably therefore not be drawn from research as it currently stands. Furthermore, even when robust dose-response effects have been found, these have been based on correlational data and so it is not possible to infer causal relationships between length and beneficial outcomes (Parsons et al. 2017; Strohmaier et al. 2020). This highlights the need to examine dose-response effects in MBPs using experimental designs, so that causal conclusions can be drawn, and in a manner that tightly controls and monitors the amount of mindfulness practice undertaken. Furthermore, it seems important to conduct this research in-person since, while online and app-delivered MBPs

often include automatic computerized measures of how often and how long a recording was being played (e.g. Bostock et al. 2018), even with these methods it is difficult to be confident regarding individuals' actual level of engagement with the mindfulness practice.

Therefore, the current study aimed to experimentally compare the impact of shorter and longer mindfulness practices when delivered face-to-face, in order both to partially test the theory underpinning MBPs and to start to provide more evidence for mindfulness teachers and MBPs with regard to dose of practice, especially for novice practitioners. Primary hypotheses to test in this study were that 1) engaging in four longer (20 minutes) mindfulness practices results in significant positive changes with regards to trait mindfulness, depression, anxiety and stress outcomes compared to a not practicing control group; 2) engaging in four shorter (5 minutes) mindfulness practices results in significant positive changes in the same outcomes compared to a not practicing control group; and 3) there is a statistically significant difference between engaging in longer and shorter mindfulness practices with longer practices resulting in larger beneficial effect sizes of outcomes. The direction of the third hypothesis was based on the above-mentioned theoretical grounds for thinking that longer mindfulness practice would lead to higher levels of mindfulness and greater benefit.

Additionally, the following secondary hypotheses were tested: 4) the total amount of time of mindfulness practice participants engage in predicts the degree of improvement; 5) change in trait and state mindfulness significantly mediates the relationship between mindfulness practice length and outcomes; and 6) the average mindfulness practice quality significantly interacts with mindfulness practice length with the combination of higher practice quality and practice length significantly predicting positive outcomes.

Method

Participants

A priori power analysis using G*Power for finding a small to medium effect (ES = 0.25) with $\alpha = 0.05$ and power of 0.95 suggested a required sample size of 66. A small to medium effect has previously been found in similar studies and reviews (e.g. Basso et al. 2019; Khoury et al. 2013). Participants were recruited through convenience and snowball sampling. Recruitment was conducted through adverts at a university, for students and staff (academic and non-academic). The study was advertised as "examining listening exercises, some of which may include some mindfulness practice".

A total of 71 individuals aged between 21-72 participated. Participants predominately identified as female (71.8%), as white British or European (90.1%), and as students, academics, or other university staff. Participants were novice practitioners with limited previous mindfulness practice experience and no current mindfulness practice. The majority of participants had never previously engaged in mindfulness practice, with a small number (N = 5) indicating that they had previously taken part in a mindfulness practice but did not currently practice; however, in all these cases, engagement in mindfulness had taken place between 5 and 10 years prior to taking part in this research. All participants denied engaging in formal mindfulness practices outside of sessions over the course of the study. As compensation, participants were entered in a prize draw to win online shopping vouchers. Psychology undergraduates could choose course credits for participating instead. The study was approved by a university ethics panel and all participants provided informed consent.

Procedure

This single-blind, four-session randomized controlled experiment had three arms: longer mindfulness practice (20 minutes) in group 1, shorter mindfulness practice (5 minutes) in group 2 and no mindfulness practice (control) in group 3. To ensure that there was no length of time effect for the three groups, participants also listened to extracts from an audiobook for 5 minutes (group 1), 20 minutes (group 2) and 25 minutes (group 3); therefore,

the exercises to be completed in each of the three different groups lasted the same length of 25 minutes. An active control group was chosen to enhance group allocation concealment and reduce performance bias. Participants were included in the study if they were i) aged over 18, ii) were novice mindfulness practitioners as defined as having limited mindfulness practice experience. Participants were precluded from participating if they were currently experiencing significant difficulties with their mental wellbeing and/or currently engaged in regular personal formal mindfulness practice or were participating in a mindfulness-based program at the time of the study.

Mindfulness Practice Recordings

The mindfulness practices were recorded by a qualified mindfulness teacher (XX). The recording was a mindfulness of the breath meditation practice similar in style to those in MBSR and MBCT (Kabat-Zinn 1990; Segal et al. 2013). The recordings were edited to create 20-minute and 5-minute practices, which included largely the same content. In the longer version, some instructions on returning attention to the breath were repeated and, in the shorter version, general instructions at the beginning of the practice relating to posture were shortened. Transcripts of both recordings are available in the supplementary materials (SM 1). In previous research by Berghoff et al. (2017), the exact same recordings for both longer (20-minute) and shorter (10-minute) mindfulness practices were used with the only difference being 10-minutes of silence being added to the end of the longer meditation practice. However, this had been identified as one of the limitations in Berghoff's study since novice practitioner participants' attention was likely compromised without being reminded to return to the breath (Berghoff et al. 2017).

Audiobook Recordings

The 5, 20 and 25 minute audiobook excerpts were from Bryson's (2003) audiobook titled A Short History of Nearly Everything. Excerpts covered non-fictional information on

the history of the earth. Previous research has found non-fictional audiobooks and podcasts to be a helpful control group with participants from the general population (e.g. Basso et al. 2019). For ease of listening, the audio recordings were never more than four seconds shorter or longer than the required length but did vary by a few seconds so that the last sentences were finished. Different excerpts were played for each of the four sessions.

Randomization

Participants were randomized to groups using block randomization with block sizes of six by the Microsoft Excel random number function RAND. Participants were blinded to group allocation. No participants dropped out from the study post-randomization. Figure 1 depicts the CONSORT flowchart (Moher et al. 2011).

--Figure 1 *CONSORT flowchart of participant flow through the study—*

Sessions

After participants were randomized to groups, they were emailed the times and locations of their four sessions, which were administered in a quiet seminar room over two weeks, with two sessions on consecutive days each week. To avoid findings being confounded by the time of day the sessions were held, the allocation of the time for each sitting and group affiliation was randomized for each session. Occasionally individual participants had to be rescheduled because they were unable to attend at short notice. Sittings typically comprised four or five participants practicing mindfulness or listening to the audiobook at the same time. The first author (XX) facilitated the sessions. The session content focused solely on listening to the audiobook and mindfulness practice and completing the questionnaires. There was no discussion of participants' experiences during meditation practice or audiobook listening, since the aim of the session was to examine the effect of practice length only. The facilitator (XX) took qualitative notes on what they observed during the sessions. At the end of the first session, participants from groups 1 (longer practice) and 2

(shorter practice) were given a handout detailing common experiences when practicing mindfulness. This detailed frequently asked questions (FAQs) that covered potential experiences that can arise during mindfulness practice and was adapted from Cavanagh et al. (2013). Participants were asked to read through it in detail at the end of the first session and participants were reminded of the handout in the following sessions.

At the beginning of the study, participants were asked not to engage in any formal mindfulness practices outside of the sessions, with this being defined as "listening to audio recordings or taking time to formally sit or lie down to practice mindfulness similar to how it is on the recordings". Participants were reminded of this at the end of every session. However, participants were made aware that if as a result of the mindfulness practices completed in the sessions, they felt more present in everyday life and were relating to present-moment experiences with more gentleness and kindness, that this was absolutely fine. Prior to every in-session practice, participants were informed that they could stop practicing at any point if they felt uncomfortable; when asked about discomfort, none reported feeling uncomfortable. In week three, participants were asked to complete the final measures online, before being debriefed. All participants in all three groups were provided details of different ways they could access mindfulness-based programs and information on additional reading on mindfulness if they so wished after the debrief (see Figure 2 for study flowchart depicting process).

--Figure 2 *Flowchart of study process—*

Measures

Participants were asked to complete the following self-report measures at the time points detailed below and in Figure 2. Where available and psychometrically robust, shorter forms of measures were selected, in light of research suggesting that participants may be less likely to accurately complete longer self-report questionnaires (Galesic and Bosnjak 2009).

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Depression, Anxiety and Stress Scale (DASS-21; Henry and Crawford 2005)

The DASS-21 is divided into three 7-item subscales of depression, anxiety and stress with each subscale ranging in scores from zero to 21 with higher scores indicating greater symptomatology. The scale has shown convergent, discriminant and construct validity and high reliability in a large sample (N = 1,794) of the UK general population (Henry and Crawford 2005). In the current sample, the total DASS-21 showed good reliability (Cronbach's α = 0.82). When examining subscales separately, this also showed good internal consistency for depression (α = 0.78), anxiety (α = 0.75) and stress (α = 0.74). Participants were asked to complete the DASS-21 at baseline, after sessions 2, 3 and 4, respectively, as well as online in week three.

Five Facet Mindfulness Questionnaire (FFMQ-15; Baer et al. 2012)

At the same timepoints as the DASS-21, participants were asked to complete the FFMQ-15, which measures trait mindfulness, the primary outcome. This questionnaire has shown high levels of convergent validity before and after a mindfulness practice program as well as high reliability in a general population sample (Gu et al. 2016). For calculation of the total scale score, it is recommended to omit the observe subscale items (Baer et al. 2012; Gu et al. 2016) resulting in scores of trait mindfulness ranging between 12 and 60. Each FFMQ-15 subscale ranges between three and 15.With the current sample, the total FFMQ-15 showed good internal consistency (Cronbach's α = 0.84). All but one of its subscales also showed good internal consistency (observe: α = 0.74; describe: α = 0.78; acting with awareness: α = 0.65; non-judging: α = 0.77; non-reactivity: α = 0.8). The FFMQ-15 was chosen as the measure of trait mindfulness instead of the trait-Toronto Mindfulness Scale (trait-TMS), since the trait-TMS is seen as being more difficult to complete for novice practitioners and arguably has slightly weaker psychometric properties than the FFMQ (cf. Ireland et al. 2018).

Practice Quality-Mindfulness (PQ-M; Del Re et al. 2013)

Immediately after each of the four mindfulness practices, groups 1 (longer practice) and 2 (shorter practice) were asked to complete the 6-item PQ-M, which is a visual analogue scale where participants are asked to indicate the quality of their practice ranging from zero to 100%. At time of writing, to the best of the authors' knowledge, this was the only tool available to measure practice quality. The PQ-M has shown adequate reliability, and convergent and predictive validity (Goldberg et al. 2014). In the current sample, the PQ-M showed moderately acceptable internal consistency (Cronbach's $\alpha = 0.68$). Since this practice quality measure is designed to be completed immediately after a mindfulness practice (Del Re et al. 2013), participants in groups 1 and 2 always listened to the audiobook prior to completing mindfulness practices in every session.

Toronto Mindfulness Scale (TMS; Lau et al. 2006)

All groups completed the TMS, a 13-item questionnaire assessing state mindfulness with the two subscales curiosity and decentering. The curiosity subscale ranges from zero to 24, the decentering subscale from zero to 28, and the total TMS score from zero to 52, with higher scores indicating greater curiosity, decentering, and overall state mindfulness, respectively. This scale has shown good reliability and incremental as well as criterion validity in participants with and without previous meditation experience from the general population (Lau et al., 2006; Medvedev et al. 2017). In the current sample, the total scale TMS showed high internal consistency (Cronbach's $\alpha = 0.94$) as did subscales (curiosity: $\alpha = 0.89$; decentering: $\alpha = 0.88$). The TMS was positioned immediately after the PQ-M to assess current state of mindfulness as soon as possible after the mindfulness practice (groups 1 and 2) or audiobook listening exercise (group 3).

Formal practice check

At the start of each session and the follow-up survey in week three, participants were given a single question asking whether they had engaged in formal mindfulness practice since the last session and, if so, to provide details.

Qualitative feedback

At the end of the final online survey (see Figure 2), participants were asked three open-ended questions on 1) the effect participating in this study had on them (if any); 2) what participants felt led to this potential effect; and 3) any additional feedback about the study.

Data Analyses

To test the three primary hypotheses, three (group) by two (timepoint: baseline vs. end of study) mixed Analyses of Variance (ANOVA) were performed in SPSS version 24 (IBM Corp. 2016) on the outcomes trait mindfulness, depression, anxiety and stress. Significant interactions were decomposed by running separate one-way ANOVAs for each group and for the two timepoints. Following the former, significant main effects of group were further decomposed by the Tukey, Bonferroni and Games-Howell tests, with all three being included as each method has differing strengths and limitations. In every case, all three tests were in agreement as to whether a finding was significant or not.

For some of the variables, there was some minor deviation from normality evident in residuals. Therefore, as a check, all analyses were repeated using robust methods, namely ANOVAs on trimmed means and associated post-hoc tests, using R version 3.6.2 (The R Foundation for Statistical Computing 2019) with the package WRS2 (Mair and Wilcox 2019). Findings from the robust methods did not meaningfully differ from the standard method and thus, for purposes of brevity, only results from the standard methods are reported in the results and results from robust analyses are added in the supplementary materials.

To test Hypothesis 4, bootstrapped linear regression analyses explored whether mindfulness practice length predicted trait mindfulness, depression, anxiety, and stress at

post-study, while controlling for baseline levels of respective outcomes. Mediation analyses were conducted using model 4 of the PROCESS macro version 3.4 by Hayes (2019) with bootstrapping set to 5000 and controlling for outcomes at baseline to test Hypothesis 5. To test Hypothesis 6, moderation analyses were completed using model 1 of PROCESS, again controlling for baseline levels of the respective outcome and with bootstrapping set to 5000.

Analyses for testing Hypotheses 4, 5 and 6 had been planned on the assumption that the total amount of mindfulness practiced would likely vary substantially within groups, due to participant attrition. However, unexpectedly all participants completed all four sessions. Therefore, moderation analyses included practice length as the dichotomous variable longer vs. shorter practice, and the regression and mediation analyses included the three groups as proxies for different lengths of mindfulness practice with separate regression and mediation analyses for each pair (longer vs. shorter practice; longer practice vs. control; shorter practice vs. control) as dichotomous predictor variables. For the mediation analyses, this resulted in a large number of comparisons ($n = 36$). To control for possible Type I errors, the Bonferroni correction was applied. Following the correction, significant results needed to have an alpha equal to or below $p = .001$ (99.9% C.I.). Therefore, the more stringent 99.9% confidence intervals ($p \leq 001$) were entered for mediation analyses. However, Bonferroni corrections have previously been criticized as being too strict and for reducing power thus increasing the possibility of Type II errors (Diz et al. 2011; Nakagawa 2004). Therefore, for mediation analyses, both uncorrected (95% C.I.; $p < .05$) as well as corrected (99.9% C.I.; $p \leq .001$) results are presented, as recommended (Clark-Carter 1997).

Qualitative data were subject to basic content analysis (Weber 1990). Data were coded by the first author (XX) and codes were assigned to broad categories. A random third of answers (33.8%; $N = 24$) for each participant group were independently assigned to codes by the second author (XX) and subject to inter-rater reliability analysis using Cohen's kappa.

Results

Demographic Characteristics

Table 1 shows participant demographics by group. At baseline, there were no significant differences in demographics between the three groups, suggesting randomization was successful. Table 2 shows data for each outcome, both at baseline and post-study.

---Table 1 *Demographic information by group and group comparison at baseline--*

--Table 2 *Outcome data at baseline (pre) and time 5 (post) by groups--*

Outcome Data

Group by time (baseline vs. end of study) mixed ANOVAs revealed significant group by time interactions for trait mindfulness, depression, anxiety, and stress (see Table 3). As detailed in Table 3, subsequent one-way ANOVAs showed that these interactions arose since at baseline the groups did not significantly differ while at post-study, they did. Significant interaction effects between group and time were also observed for FFMQ-15 subscales. When examining time and group effects in separate ANOVAs, no significant difference in group was found at baseline; however, at the end of the study there were significant group differences. Specifically, engaging in shorter or longer mindfulness practices resulted in significantly greater trait mindfulness and significantly lower depression, anxiety and stress compared to controls, thus confirming Hypotheses 1 and 2. Furthermore, at the end of the study, a statistically significant difference between longer and shorter mindfulness practices was observed for the trait mindfulness and the stress outcomes. However, this finding was in reverse to that hypothesized, since shorter as opposed to longer mindfulness practice resulted in larger effects; Hypothesis 3 was therefore not confirmed. For depression and anxiety, no statistically significant difference was found between the longer and the shorter practice groups at post-study. Results of within group ANOVAs, which examined change over time for each group separately, showed significant changes in expected directions for the longer

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practice group as well as for the shorter practice group and no significant change for the control group (Table 3).

   --Table 3 *Results of mixed ANOVA, Between Group ANOVA and Within Group ANOVA*--
Tables with more detailed post hoc results as well as results for each of the FFMQ-15 subscales are available in the supplementary materials (Tables SM.1, SM.2, SM.3). Figure 3 illustrates how outcome measures changed across all five time points, showing trends that are consistent with the baseline – end of study analysis. Equivalent graphs for the FFMQ-15 subscales are available in the supplementary materials (Figure SM.1).

--Figure 3 *Change in outcomes across time points by groups*--

Due to lack of attrition from the study, the planned regression analyses added little beyond the ANOVAs presented above (see Table SM.4 in supplementary materials for regression results). Unsurprisingly, given the unexpected finding of shorter practice showing larger effects on outcomes than longer practice, the scatterplots showed an inverted U-shaped effect of practice length on outcomes (e.g. see Figure 4). Hypothesis 4 was therefore not confirmed.

--Figure 4 *Inverted U-shape of practice length for trait mindfulness change*--

Effect of the Mediators Trait Mindfulness and State Mindfulness

Figures 3 and 5 show the change in trait and state mindfulness over time. Graphs for curiosity and decentering TMS subscales are available in the supplementary materials (Figure SM.2).

--Figure 5 *State mindfulness change over time*--

Boot-strapped mediation analyses examined whether trait and state mindfulness change statistically mediated the relationship between group assignment and end of study depression, anxiety, and stress levels. Separate analyses were conducted for each combination of mediator and outcome. In each analysis, baseline levels of the included outcome were

controlled for by entering this as a covariate. Due to non-linearity of practice length, separate analyses were conducted for each pairing of groups.

From uncorrected mediation analyses, neither trait nor state mindfulness change were significant mediators between shorter vs. longer practice length and depression, anxiety or stress outcomes. Trait mindfulness change was a significant mediator between the predictors longer practice vs. control and depression ($b = .6$; SE(boot) = .31; 95% C. I. [.02, 1.27]) as well as shorter practice vs. control and depression ($b = 6.62$; SE(boot) = 1.72; 95% C. I. [3.22, 9.99]). For the anxiety outcome, trait mindfulness change ($b = 2.58$; SE(boot) = 1.39; 95% C. I. [.61, 6.13]) and state mindfulness change ($b = 2.75$; SE(boot) = 1.15; 95% C. I. [.66, 5.14]) as well as change in curiosity ($b = 1.51$; SE(boot) = .74; 95% C. I. [.22, 3.1]) and decentering ($b = 2.81$; SE(boot) = 1.21; 95% C. I. [.42, 5.19]) significantly mediated the relationship between length (shorter practice vs. control) and anxiety. Results of uncorrected meditation analyses for the indirect effects are shown in the supplementary materials in Table SM.5.

However, results of corrected mediation analyses (99.9% C. I.; $p \leq .001$) showed that only trait mindfulness change remained a significant mediator of the relationship between practice length (shorter practice vs. control) and the depression outcome at post-study (time 5) when controlling for baseline depression with trait mindfulness change significantly predicting small to moderately lower depression at time five (post-study). Figure 6 illustrates the mediation model diagram. Corrected mediation models for outcomes with non-significant indirect effects are available on request from the corresponding author.

--Figure 6 *Corrected meditation model shorter practice vs. control, trait mindfulness change, depression outcome--*

Hypothesis 5 could only partially be confirmed since trait and state mindfulness change were significant mediators for only some outcomes in both corrected and uncorrected models.

Effect of the Moderator Practice Quality

The following results are reported since they were part of the pre-planned analysis. However, these should be interpreted with caution given the relatively low internal consistency mentioned above and other potential limitations of this measure in the context of this study, details of which are discussed below.

Moderation analyses revealed that there was no significant interaction between practice length (longer vs. shorter) and practice quality when predicting any of the outcomes, as indicated by the length x quality interaction term failing to increase the amount of variance explained in trait mindfulness ($F(1, 43) = 0.36$, $\Delta R^2 = 0.003$, $p = .55$), depression ($F(1, 43) = 0.83$, $\Delta R^2 = 0.014$, $p = .37$), anxiety ($F(1, 43) = 0.19$, $\Delta R^2 = 0.002$, $p = .67$) or stress ($F(1, 43) = 0.31$, $\Delta R^2 = 0.005$, $p = .58$). Thus, Hypothesis 6 was not supported. Graphically, practice quality appears to be increasing more steadily in the group of shorter mindfulness practitioners compared to the longer practice group (see Figure 7 for practice quality change over time).

--Figure 7 *Practice quality change over time*--

Qualitative Participant Feedback

Inter-rater reliability analysis of independent content analysis resulted in a Cohen's kappa of $\kappa = .93$, which represents almost perfect agreement (McHugh 2012). Results of the content analysis showed 34 comments on positive experiences of mindfulness practice in the longer practice group compared to 75 comments on positive experiences of practice in the shorter practice group. Particularly compelling are comments from participants in the shorter practice group such as "when I'm feeling negative or scared I now go to my breathing which I never did before" and "doing the mindfulness practice in the study put my mind in a positive mindset the rest of the day." The perceived benefits of brief mindfulness practices were also reflected in 16 comments from participants in the shorter practice group with

comments such as "I always thought that to do mindfulness, I'd need a long time to dedicate to this which seemed too challenging to even start. But I've learned that 5 minutes can help!".

Contrarily, there were 18 comments from participants in the longer practice group who expressed some difficulties with practice particularly relating to its length, with comments such as "I think a shorter one would be better for me to learn mindfulness" and "I sometimes found it quite difficult to stop my mind from wandering". Finally, five participants in the longer practice group declared the study to have had no effect compared to 13 in the control group. Participants in the shorter practice group neither expressed difficulties with practice nor stated that the study had no effect. Detailed results of the content analysis are available on request from the corresponding author.

Facilitator Observations

While not part of the formal pre-planned data collection, the facilitator of the sessions (XX) observed the following, which potentially contributed to the understanding of the findings: 1) after the end of the study, five participants in the shorter practice group were sufficiently interested in the mindfulness practice to spontaneously ask for the mindfulness practice track so they could continue practice, while no participants in the longer practice group asked for this; 2) in their contemporaneous notes of the session which were taken before data analysis and knowledge of results, the facilitator observed that participants in the longer practice group tended to fidget, shift in their seat, and open their eyes more frequently, whereas this was observed less in the shorter practice group. Limitations of these informal observations are considered in the discussion below.

Discussion

The purpose of this study was to examine the effect of two different tightly controlled lengths of mindfulness practice for novice practitioners over four face-to-face sessions compared to an active control. Results showed that engaging in shorter and longer mindfulness practices

both had significant beneficial effects on trait mindfulness, depression, anxiety and stress, relative to an active control; thus confirming Hypotheses 1 and 2. This corresponds with previous findings that both longer as well as shorter mindfulness practices can improve trait mindfulness as well as psychological distress outcomes (e.g. Janssen et al. 2018; Mahmood et al. 2016).

Hypothesis 3, that engaging in longer mindfulness practices would result in a larger effect than engaging in shorter practices, was not confirmed. In fact, this effect was reversed, since completing shorter practices had a significantly larger effect on trait mindfulness and stress than longer practices; there was a non-significant trend in the same direction for depression and anxiety. This finding was further elucidated by results of the content analysis with more comments about positive experiences being made by participants in the shorter practice than the longer practice group. Additionally, this result coincides to an extent with the lack of dose-response relationships identified in Strohmaier's (2020) meta-regression, since both long as well as short programs appear helpful for depression, anxiety, and stress. It does not however confirm the positive dose-response relationship between actual MBP use and trait mindfulness found in Strohmaier's meta-regression, since engaging in shorter rather than longer practices resulted in greater trait mindfulness change in the current study. However, actual MBP use did not only include practice but also other learning elements of mindfulness programs (Strohmaier 2020), whereas in this study, mindfulness practice isolated from other such elements was examined.

The findings in this study also do not correspond with a previous review of MBSR and MBCT by Parsons et al. (2017), who found a small, positive correlation between longer self-reported home practice and outcomes. However, in Parsons et al.'s review, practice time was not controlled tightly as it is in the present study since self-reported home practices rather than in-person practices were measured. Additionally, it is unclear in both above

reviews how much prior mindfulness practice experience participants from included studies had. When asked for the effects of the current study, novice practitioners in the longer but not the shorter practice group mentioned that at times they experienced some difficulties in holding concentration and avoiding mind-wandering during practice and a number of participants in the longer practice group asked whether there was a shorter alternative to mindfulness practice. This coincides with findings from previous research suggesting novice practitioners can find longer practices challenging and can experience mind-wandering during such practices (Banerjee et al. 2017; Frewen et al. 2016). It may be that when mindfulness is taught to novices with relatively little additional teacher input beyond practice guidance (as was the case in the current study), challenges associated with longer practices, such as mind-wandering, led them to be less effective in general than shorter ones (cf. Desbordes et al. 2015; Frewen et al. 2016). However, in contrast, it is possible that the increased teacher input present in some MBPs (e.g. the teacher-led enquiry in MBSR and MBCT), may help participants to reframe and remain engaged with such challenges and thus benefit more from longer practices in such MBPs (cf. Segal et al. 2013). This may help explain the difference between the dose-response effect observed here and those found by Parsons et al. (2017) and Strohmaier (2020). If this account is correct, an important implication is that optimal amount of mindfulness practice may depend upon amount of teacher-led enquiry included in an MBP, with self-help MBPs that do not include this likely benefitting from substantially shorter practices (cf. Segal et al. 2013). This should be a focus of future research.

Regardless, a noteworthy finding from the current study is that practicing mindfulness for just 5 minutes on four occasions, over two weeks, can significantly improve individuals' trait mindfulness, and depression, anxiety, and stress levels. This is further elucidated by a number of participants particularly valuing the shorter practices in the current study and

commenting on the impact they felt it had on their daily life. The value of shorter practices in reducing stress resembles findings from a previous study with healthy employees where engaging in brief mindfulness practices significantly reduced work-related stress (Bostock et al. 2018). Additionally, this result aligns with the finding of increased trait mindfulness after brief, app-delivered mindfulness practices in university students (Flett et al. 2019). Shorter practices may thus feel more attainable and sustainable for novice practitioners, especially when there is minimal ongoing teacher input and prior practice experience. The positive qualitative feedback responses from the shorter practice participants further support this claim. Consistent with this, some people from the shorter practice group and none from the longer practice group requested the practice recording to continue their practice after the end of this study and the facilitator observed more fidgeting and eyes opening in the longer practice group (though see below for limitations of these data).

For anxiety and depression outcomes, there were no significant differences at post study between longer and shorter practices, although there was a trend towards favoring shorter practices. One possible explanation for this result may be that engaging in mindfulness practices regardless of length may be helpful in reducing rumination and worry, since the quality of practices completed rather than simply the time spent practicing may be of importance (Ribeiro et al. 2018). Additionally, this result coincides with previous research comparing 20-minute and 10-minute home practices over a two-week mindfulness program where no difference in effectiveness between the longer and the shorter practice was found for depression and anxiety (Berghoff et al. 2017).

Mediators Trait and State Mindfulness and Moderator Practice Quality

When assessing underlying processes of practice length on outcomes, results from uncorrected mediation analyses showed significant mediating effects of trait mindfulness change between both practices vs. control for depression. Additionally, significant mediating

effects of trait and state mindfulness change between shorter practice vs. control and anxiety were found. However, in the corrected mediation analysis, only the model of trait mindfulness change as a mediator between shorter practice vs. control and depression remained significant. This coincides with previous research identifying trait mindfulness as an underlying mechanism of MBPs for psychological wellbeing (Gu et al. 2015). For both, uncorrected and corrected results, neither trait nor state mindfulness change significantly mediated the relationship between practice length when defined as longer vs. shorter practice and all outcomes.

Turning to moderation, Hypothesis 6 was not confirmed since mindfulness practice quality did not significantly moderate the effect of different practice lengths on outcomes. Graphically, participants engaging in both practices showed consistently high quality. This coincides with previous research where practice quality was a significant predictor for psychological outcomes at post-program and follow-up even when average practice time was controlled for (Goldberg et al. 2014). One possible explanation of the failure to find a moderating effect of practice quality is that accurate measurement of this has been identified as being difficult (Parsons et al. 2017; Ribeiro et al. 2018). Additionally, it is possible that there was insufficient variation in practice quality between the groups to observe an effect.

Limitations and Future Research

Using the PQ-M to measure practice quality was a possible limitation of this study. According to Del Re et al. (2013), the PQ-M is generally used for longer MBPs such as MBCT and MBSR. Additionally, in Del Re et al.'s study, 42% of participants had prior meditation experience and thus may have been more familiar with mindfulness-related terms used in the PQ-M. In this study however, participants purposely were only included if they had limited prior meditation experience. Additionally, no discussion with a facilitator took place since the focus of this study was to examine isolated practice length. Participants may

therefore have been less familiar with the mindfulness terms employed in the PQ-M. Anecdotally, some participants mentioned that they perceived the PQ-M as confusing to complete. This was also reflected in the reliability analysis of the PQ-M showing internal consistency to be below the acceptable threshold in this sample. However, given that this measure has been used in previous similar studies and, to the authors' knowledge, is currently the only relevant published tool to measure mindfulness practice quality, it was deemed appropriate to use in this study. With hindsight, arguably the PQ-M was not a good choice of measure of practice quality for this study and results relating to practice quality should be treated with substantial caution. Future research may benefit from employing a questionnaire designed to measure practice quality specifically in novice practitioners, once that exists. From qualitative facilitator observations, there was some evidence of difference in practice quality or difficulty in staying with experience between groups. However, these were not formally measured, and it would be important for future research to more formally record these and include independent ratings of these by individuals not aware of the practice conditions, in order to reduce potential sources of bias in these data.

Additionally, previous research has found that items on the TMS measure can be more difficult to complete for individuals with little knowledge of mindfulness (Ireland et al. 2018), which could have impacted results. However, the TMS is presently the most widely used and validated measure of state mindfulness and research, including results of this study, have still found significant increases in state mindfulness in individuals with little experience of mindfulness (Lau et al. 2006; Medvedev et al. 2017).

Another limitation of the study was the possibility of common method bias having occurred due to multiple constructs being measured through multiple-item self-report measures (Podsakoff et al. 2003). This seems unlikely to have influenced the differences observed between the three groups, as there was no obvious reason for this bias to have

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systematically varied between groups. However, it could have contributed to the analyses based on correlations between the variables measured by the self-report scales, most notably the mediation analyses. Some efforts were made to minimize this, such as assuring anonymization and advising participants that there were no right or wrong answers and to respond as honestly as possible (Podsakoff et al. 2003). However, it still may have contributed to the mediation findings.

Moreover, it would be valuable to complete a further experimental examination of mindfulness practice length with experienced, long-term mindfulness practitioners to determine the possible effects of different practice lengths for this group and whether altering practice length would have effects on trait mindfulness and psychological distress outcomes. The effects of practice quality and state and trait mindfulness would again be valuable to explore in a more experienced sample. Additionally, the study sample was limited in only including a non-clinical sample and findings are thus not generalizable across other populations. In future, this research could be duplicated with clinical populations with various mental or physical health difficulties to further understanding on effects of different practice lengths for these populations.

Furthermore, only two different lengths of practice over a reasonably short time were explored in this study; conclusions about other practice lengths and session numbers can therefore not be drawn. This was completed to be able to compare a shorter to a longer practice in a controlled way. Additionally, only formal mindfulness practices were examined here without exploring the effects of length in informal practices, which arguably would be important to consider (Ribeiro et al. 2018). In future research, this study could be repeated to explore effects of different practice and program lengths for formal and informal practices. As discussed earlier, future research could also examine the hypothesis that dose-response effects may be moderated by the amount of teacher-led enquiry included in the MBP, with

shorter practices being more beneficial than longer ones when there is minimal enquiry and the reverse when there is more substantial teacher involvement.

Furthermore, non-significant mediation and moderation results were found for practice length (when defined as longer vs. shorter practice) with practice quality and trait and state mindfulness change as moderator and mediators, respectively. This lack of significant mediation and moderation effects could have been due to Type II errors, especially given the high threshold required to attain significance when the control for multiple comparisons was applied to the mediation (Nakagawa 2004). However, it is worth noting that mediation and moderation were not the primary analyses in this study.

Finally, it was not possible to state with complete certainty that participants in this study actively engaged in practice rather than simply listening to recordings or letting their minds wander. However, the aim of this study was to isolate and control mindfulness practice length in-person as much as possible to ascertain effects of different practice lengths on outcomes and the changes in trait and state mindfulness would suggest that participants were engaging.

Data Availability Statement

Materials used in the study are either referenced in the references list or, where they were new to the study (i.e. transcripts of mindfulness practice recordings), are provided in the Supplementary Materials. Participant permission was not sought to make raw data available, though it is planned to do so for future studies.

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Table 1

Demographic information by group and group comparison at baseline

	Whole sample	Longer practice	Shorter practice	Control	Group comparison
N	71	24	24	23	
Age M (SD)		36.58 (12.54)	41.17 (14.31)	40.43 (15.69)	$\chi^2 = 76.72$ $p = .13$
Gender (% female)	71.8%	70.8%	83.3%	60.9%	$\chi^2 = 2.95$ $p = .23$
Ethnicity *N* (%)	White: 60 (90.1%) Black: 3 (4.2%) Asian: 2 (2.8%) Other: 2 (2.8%)	White: 19 (87.5%) Black: 1 (4.2%) Asian: 1 (4.2%) Hispanic: 1 (4.2%)	White: 19 (87.5%) Black: 1 (4.2%) Asian: 1 (4.2%) Arab: 1 (4.2%)	White: 22 (95.7%) Black: 1 (4.3%)	$\chi^2 = 7.27$ $p = .7$
Occupation *N* (%)	Student: 32 (45.1%) Lecturer: 15 (21.13%) Administrator: 9 (12.67%) Librarian: 5 (7.04%) Teacher: 2 (2.82%) Manager: 2 (2.82%) Other: 6 (8.45%)	Student: 12 (50%) Lecturer: 9 (37.5%) Administrator: 2 (8.3%) Counsellor: 1 (4.2%)	Student: 8 (33.3%) Lecturer: 3 (12.5%) Administrator: 6 (25%) Librarian: 3 (12.5%) Teacher: 1 (4.2%) Writer: 1 (4.2%) Manager: 2 (8.3%)	Student: 12 (52.2%) Lecturer: 3 (13%) Administrator: 1 (4.3%) Librarian: 2 (8.7%) Teacher: 1 (4.3%) Research fellow: 1 (4.3%) Director 1 (4.3%) IT analyst: 1 (4.3%) Retired: 1 (4.3%)	$\chi^2 = 5.16$ $p = .27$

Note: N=Number; *M*=Mean; *SD*=Standard Deviation.

Table 2

Outcome data at baseline(pre) and time 5 (post) for longer practice, shorter practice, and control

Outcome	Longer practice		Shorter practice		Control	
	Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)	Pre M (SD)	Post M (SD)
Trait mindfulness	35.5	45	34.2	52.67	38	37.48
(FFMQ-15 total)	(7.98)	(4.55)	(6.74)	(2.06)	(6.73)	(6.87)
FFMQ-15 Observe	8.21	10.79	8.13	12.79	8.39	8.3
	(2.32)	(1.93)	(2.51)	(1.53)	(2.84)	(2.93)
FFMQ-15 Describe	9.63	11.46	8.63	12.92	9.52	9.57
	(2.96)	(1.93)	(2.14)	(1.14)	(2.23)	(2.09)
FFMQ-15 Act Aware	8.04	10.71	8.46	13.58	8.57	8.74
	(1.97)	(1.33)	(2.48)	(0.93)	(1.95)	(1.98)
FFMQ-15 Non-Judge	10.5	12.71	9.71	13.29	11.22	11.61
	(3.4)	(2.12)	(2.48)	(1.4)	(2.37)	(4.9)
FFMQ-15 Non-react	7.33	10.29	7.42	12.29	8.7	8.43
	(2.57)	(1.55)	(2.04)	(0.95)	(2.58)	(2.5)
DASS-21 Depression	7.67	2	8.25	0.83	4.87	5.04
	(5.86)	(2.28)	(6.05)	(1.17)	(4.55)	(4.74)
DASS-21 Anxiety	6	1.75	4.25	0.83	5.57	5.65
	(6.07)	(1.98)	(4.61)	(1.31)	(6.06)	(5.96)
DASS-21 Stress	11.67	4.17	11.83	1.75	10.87	10.52
	(5.71)	(2.43)	(7.48)	(1.59)	(5.15)	(5.3)

Note: M=Mean; *SD*=Standard Deviation; FFMQ-15=Five Facet Mindfulness Questionnaire; DASS-21=Depression Anxiety Stress Scale

Table 3

Results of mixed ANOVA, Between Group ANOVA and Within Group ANOVA

Outcome	group*time	Between groups		Within group (time)		
		Baseline	Post	Longer practice	Shorter practice	Control
Trait mindfulness	$F(2,68) = 44.7^{***}$	$F(2,68) = 1.69$	$F(2,68) = 57.13^{***}$ a***b***c***	$F(1,46) = 25.65^{***}$	$F(1,46) = 164.5^{***}$	$F(1,44) = 0.07$
Depression	$F(2,68) = 17.72^{***}$	$F(2,68) = 2.48$	$F(2,68) = 11.62^{***}$ b**c***	$F(1,46) = 19.5^{***}$	$F(1,46) = 34.75^{***}$	$F(1,44) = 0.02$
Anxiety	$F(2,68) = 8.67^{***}$	$F(2,68) = 0.63$	$F(2,68) = 11.41^{***}$ b**c***	$F(1,46) = 10.62^{**}$	$F(1,46) = 12.16^{**}$	$F(1,44) = 0.002$
Stress	$F(2,68) = 20.1^{***}$	$F(2,68) = 0.16$	$F(2,68) = 40.2^{***}$ a*b***c***	$F(1,46) = 35.1^{***}$	$F(1,46) = 41.7^{***}$	$F(1,44) = 0.05$

Note: Trait mindfulness measured with Five Facet Mindfulness Questionnaire (FFMQ-15); Depression, Anxiety, Stress measured with Depression Anxiety and Stress Scale (DASS-21); *** $p < .001$; **$p < .01$; *$p < .05$; a=significant difference between groups 1 (longer practice) & 2 (shorter practice) post hoc; b= significant difference between groups 1 (longer practice) & 3 (control) post hoc; c=significant difference between groups 2 (shorter practice) & 3 (control) post hoc. Post hoc tests used: Bonferroni, Tukey, Games-Howell (for more detail, see supplementary materials)

Figure 1

CONSORT flowchart of participant flow through the study (Moher et al. 2011)
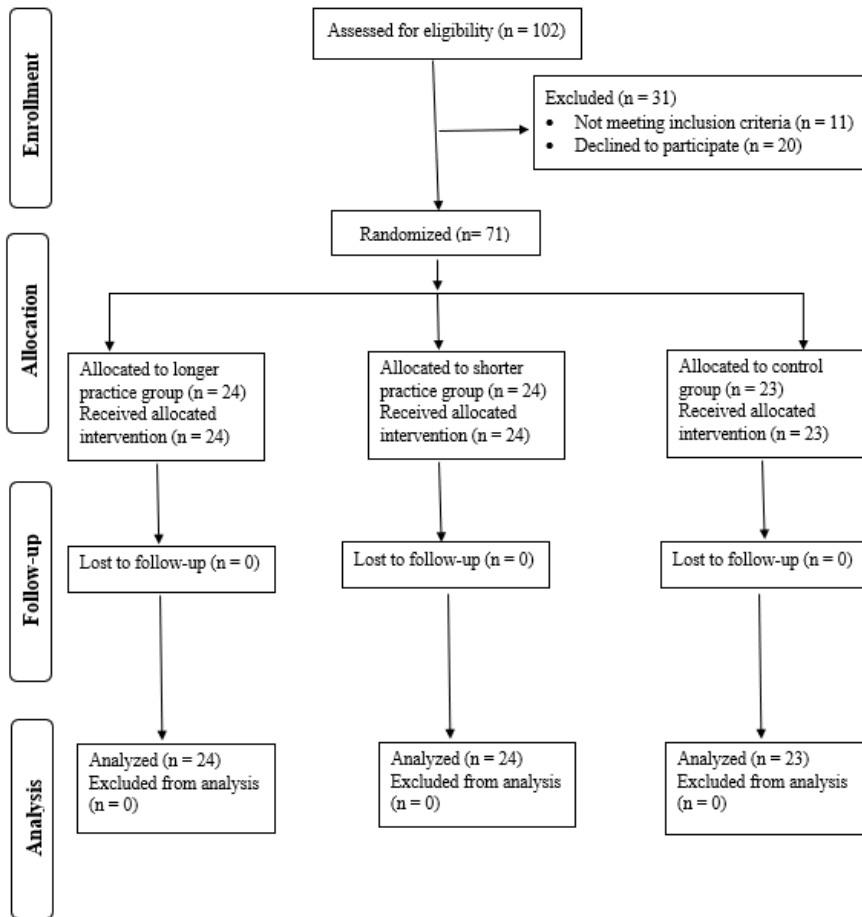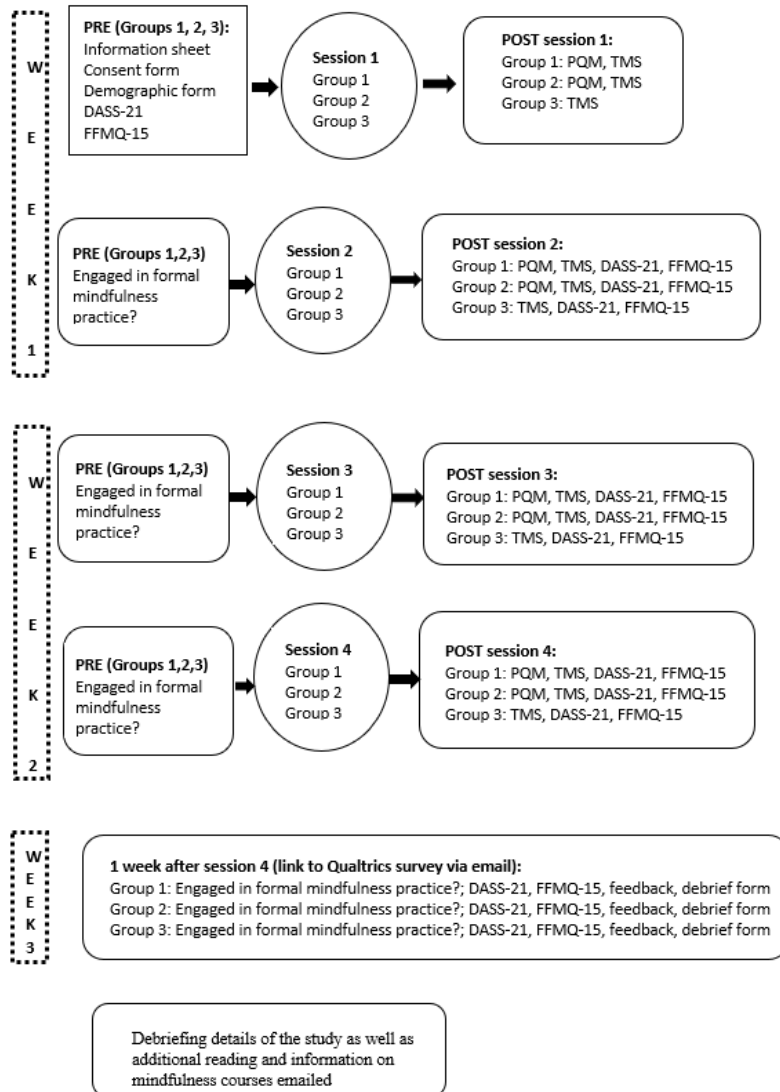
Figure 2

Flowchart of study process

Note: Order of groups counterbalanced for every session; DASS-21=21-item Depression, Anxiety and Stress Scale; FFMQ-15=15-item Five Facet Mindfulness Questionnaire; PQM=Practice Quality-Mindfulness; TMS=Toronto Mindfulness Scale.

Figure 3

The change in outcome measure across all time points, from baseline (time 1) to end of study (time 5), for group 1 (longer practice), group 2 (shorter practice) and group 3 (control). Top left: trait mindfulness (FFMQ-15). Top right: depression (DASS-21). Bottom left: anxiety (DASS-21). Bottom right: stress (DASS-21).
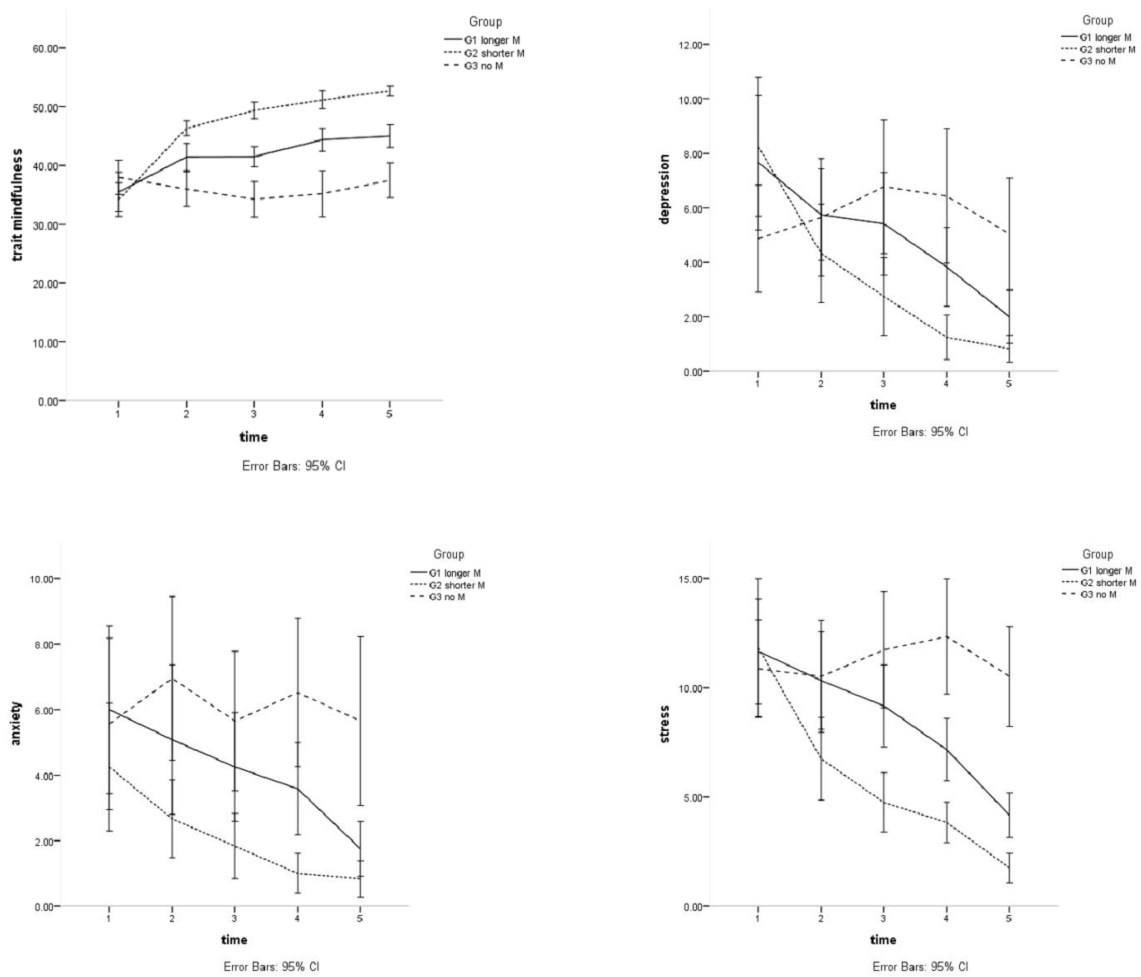
Figure 4

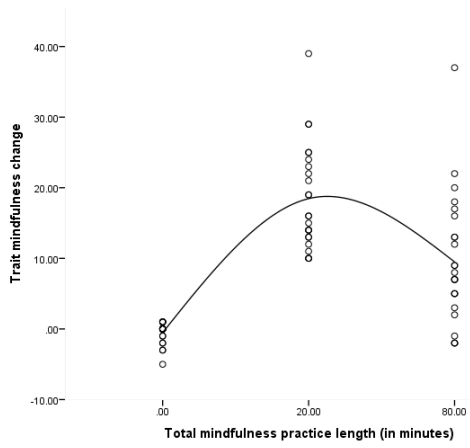*Inverted U-shape of practice length for trait mindfulness change*

Figure 5

State mindfulness change over time (session 1 to 4) for group 1 (longer practice), group 2 (shorter practice) and group 3 (control)
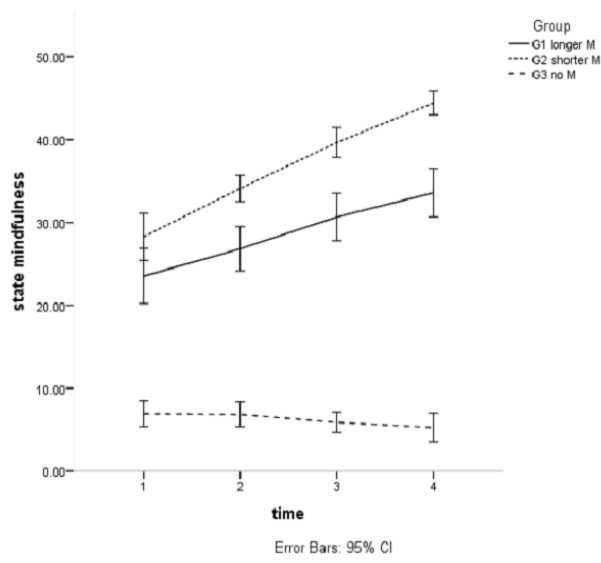
Figure 6

Mediation model for post-study (time 5) depression with length (shorter practice vs. control) as predictor, trait mindfulness change as mediator and baseline depression as a covariate. Top diagram: total effect when excluding mediator, bottom diagram: indirect and direct effects when including mediator (*p < .05; **p < .01; ***p < .001; 99.9% CI=99.9% Confidence Intervals; significant results based on 99.9% C.I. in bold)
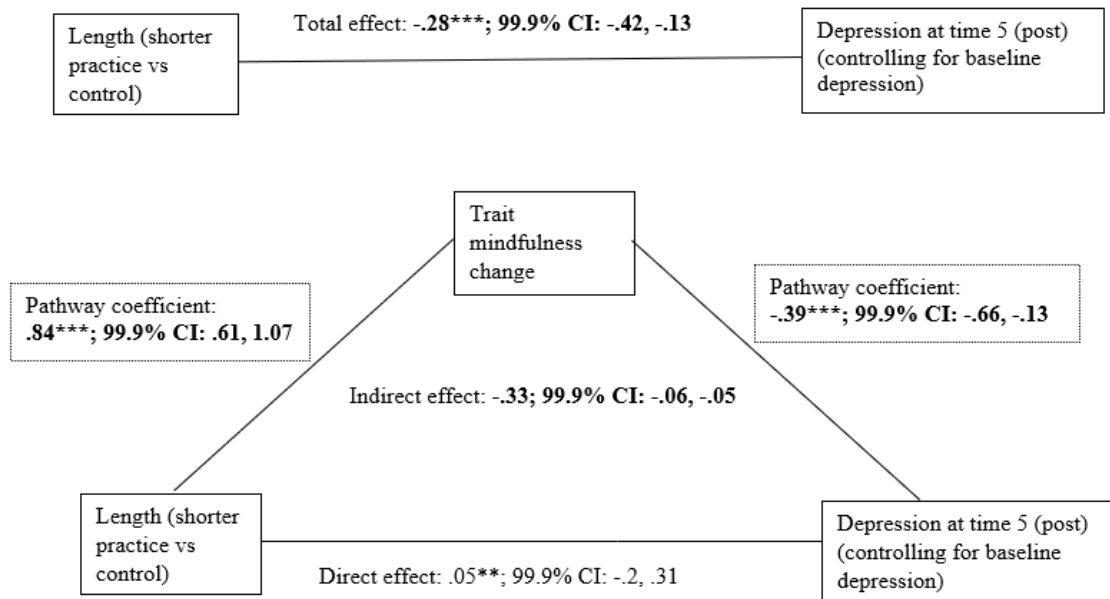
Figure 7

Mindfulness Practice Quality change for group 1 (longer practice) and group 2 (shorter practice) over time (sessions 1 to 4)