# Efficacy of a mindfulness-based programme with and without virtual reality support to reduce stress in university students: A randomized controlled trial

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## Highlights

- High levels of stress are often experienced by university students.
- MBPs are effective for reducing perceived stress in this population.
- Mindfulness and self-compassion partially mediate the long-term effects of the MBP.
- Virtual reality exposure may improve participants' adherence to MBPs.


## Abstract

**Objectives**: To evaluate the efficacy of a mindfulness-based programme (MBP) for reducing stress in university students and its action mechanisms and to explore the capacity of virtual reality (VR) exposure to enhance adherence to the intervention. **Methods**: This randomized controlled trial (RCT) involved assessment time points of baseline, posttreatment, and 6-month follow-up. A total of 280 students from two Spanish universities were randomly assigned to 'MBP', 'MBP+VR', or 'Relaxation' (active controls). Perceived stress posttreatment was the primary outcome; wellbeing and academic functional outcomes were assessed as well. Multilevel mixed-effects models were performed to estimate the efficacy of the programme. **Results**: Both 'MBP' (*B*=-2.77, *d*=-0.72, *p*=.006) and 'MBP+VR' (*B*=-2.44, *d*=-0.59, *p*=.014) were superior to 'Relaxation' in improving stress, as well as most of the secondary outcomes, with medium-to-large effects posttreatment and at follow-up. The long-term effects of MBPs on stress were mediated by mindfulness and self-compassion in parallel. Treatment adherence was improved in the 'MBP+VR' group, with higher retention rates and session attendance (*p*<.001). **Conclusions**: This RCT supports the efficacy of an MBP compared to relaxation for reducing stress in university students through mindfulness and self-compassion as mechanisms of change. VR exposure may enhance treatment adherence. **Trial registration:** ClinicalTrials.gov NCT03771300



**Keywords:** university students, mindfulness, virtual reality, psychological wellbeing, stress, randomized controlled trial.

## 1. Introduction

The mental health of university students is a noteworthy concern. Several studies have acknowledged high levels of stress in this population, with prevalence estimations of 29-37% (Jia & Loo, 2018; Yusoff et al., 2010). University students are continually striving to achieve goals, and their performance is constantly being evaluated (Caballero and Breso 2015), which generates a great amount of stressors, such as tests, the large amount of content to be learnt, lack of time, getting poor marks, and living up to one's own expectations (Yusoff et al., 2010).

The impact of stress on university students can lead to psychological distress and, in some cases, the development of psychopathologies. A project conducted by institutions of higher education across eight countries found that 35% of the 13,948 first-year college students respondents screened positive for at least one common lifetime disorder (i.e., major depression disorder, mania/hypomania, generalized anxiety disorder, panic disorder, alcohol abuse or dependence, and drug abuse or dependence), and 31% screened positive for at least one disorder in the previous 12 months (Auerbach et al., 2018). Similarly, other studies indicate a high prevalence of psychological distress, anxiety and depression among university students (Dyrbye et al., 2006; Ibrahim et al., 2013; Stallman, 2010) and a high prevalence of suicidal thoughts and self-harming behaviours (Mortier et al., 2018). Therefore, universities are challenged to set up effective preventive interventions to help students better cope with university life and improve their mental health.

It has been observed that cognitive, behavioural and mindfulness-based programmes (MBPs) are effective in reducing stress and improving mental health in university students (Bamber & Morpeth, 2019; Bamber & Schneider, 2016; Dawson et al., 2019; O'Driscoll et al., 2019; Ma et al., 2019; McConville et al., 2017; Halladay et al., 2019; Regehr et al., 2013). MBPs are encompassed within the so-called 'third-wave' psychotherapies, which focus on aspects such as mindfulness, compassion, cognitive fusion, acceptance, and spirituality (Jahoda et al., 2017). MBPs' primary aim is to train the mind to adopt a non-judgemental present-focused awareness (Conley et al., 2017). In recent years, these interventions have been expanded and have proven to be effective in a variety of clinical and non-clinical populations (Demarzo et al., 2015; Gotink et al., 2015; Khoury et al., 2013). This expansion has allowed the benefits of mindfulness practice to be studied in university students (De Vibe et al., 2013; Dvořáková et al., 2017;

Kuhlmann et al., 2016; Lynch et al., 2018; Van D'Ijk et al., 2017). A study in a large sample of students from the University of Cambridge (UK) showed that an MBP reduced self-reported psychological distress during the examination period compared to support as usual, showing moderate effects (Galante et al., 2018). These beneficial effects might last for a year, but loss to follow-up was an important limitation (Galante et al., 2020). Different studies have analysed the mechanisms of action of MBPs on wellbeing and health-related outcomes; mindfulness and self-compassion have been identified as possible mediators, although the methodological limitations of most studies (e.g. not considering temporality, lacking an active control condition) imply the need of replicating and expanding these results (Gu et al., 2015).

Despite all the positive evidence supporting their effectiveness, a notable shortcoming of MBPs applied in university students is, as with most brief psychotherapies, the low adherence rates reported (Khoury et al., 2013; Pedrelli et al., 2015), with attrition values up to 63% in some cases (Nam & Toneatto, 2016). This highlights the need of identify innovative ways to make these interventions more appealing to this population. In this regard, since the 1990s, virtual reality (VR) has been increasingly used with different purposes in the field of clinical psychology, mainly for recreating scenes for virtual exposure in cases of anxiety disorders (e.g. agoraphobia, specific phobias, social anxiety) that could generate the required emotional responses for the counter-conditioning effect to take place (Diemer et al., 2014). The efficacy of VR exposure has been widely studied and is not only limited to anxiety disorders (Carl et al., 2019), as it has also been reported for stress-related disorders (Kothgassner et al., 2019) or pain-related conditions (Malloy & Milling, 2010), among others.

Nonetheless, VR has also been used for learning abilities; Jensen & Konradsen (2018) concluded that this approach was a helpful resource for the acquisition of cognitive, psychomotor, and emotional skills. Mindfulness, understood as an emotion-regulation skill, could therefore be trained via VR exposure; despite it could seem somehow counterintuitive that virtual scenarios could help the development of present-focused awareness, some works have concluded that VR exhibits high acceptability for the practice of mindfulness exercises, together with a significant increase in mindfulness state and an improved emotional state after just one VR mindfulness practice session in experienced meditators (Chandrasiri et al., 2020; Flores et al., 2018; Gomez et al., 2017; Navarro-Haro et al., 2017). Moreover, it needs to be noted that some studies have even

observed a significant booster effect on treatment adherence when VR exposure was part of the mindfulness intervention; that was the case of the study conducted by Navarro-Haro et al. (2019), who found that 100% of patients with anxiety who had been assigned to the mindfulness programme with VR exposure finished the programme, compared to a 70% in the case of those who received a classic MBP. In the case of university students, the implementation of additional virtual reality scenarios into the practice of mindfulness meditation exercises could be particularly well accepted because of their high affinity for new technologies (Furlong & Davies, 2012). In order to test if VR can really help MBPs to overcome their typically low adherence rates among undergraduates, more studies are required.

The primary objective of this three-armed randomized controlled trial (RCT) was to test an MBP's effect on university students' perceived stress compared to a relaxation programme in the Spanish context. Relaxation programmes have consistently proven effective for reducing stress levels in university students (Dolbier & Rush, 2012; Gallego-Gómez et al., 2020; Reiss et al., 2019), and thus, relaxation therapy was chosen as an active control comparator. Secondarily, the present work examined the possible mediational effects of mindfulness and self-compassion on potential long-term changes produced by the MBPs on perceived stress. We also aimed to explore the potential benefits of including VR exposure with the provision of mindfulness training to enhance treatment adherence. Finally, this study explored the effect of the mindfulness programme on other psychological health-related variables, such as anxiety, affectivity, and emotion regulation, which had been previously studied as relevant outcomes when addressing university students (Delgado-Pastor et al., 2015; Dundas et al., 2017; Halladay et al., 2019; McConville et al., 2017); in addition, academic engagement and burnout levels were included as secondary variables, as previous evidence suggested that the MBPs produce significant improvements in both of them in other populations (Coo & Salanova, 2018; Ireland et al., 2017), and both have been reported to be strongly associated to academic performance (Schaufeli et al., 2002).

We hypothesized that MBPs would be more efficacious than the active control condition, achieving significant reductions in perceived stress (i.e., the primary outcome) at the primary endpoint (i.e., posttreatment). Secondarily, we also expected this effect to be maintained at the 6-month follow-up and MBPs to be more efficacious than the relaxation control group for improving anxiety, affectivity, academic engagement,

student burnout, and emotion regulation, both posttreatment and after 6 months follow-up. We further hypothesized that allocation to MBPs (vs. control group) would be predictive of a significant improvement in mindfulness and self-compassion skills, which in turn would predict a significant reduction in perceived stress. Finally, we expected that VR exposure would significantly increase adherence to the MBP.

## 2. Methods

### 2.1. Design

The research design was a 6-week parallel RCT with three arms ('MBP', 'MBP+VR', and 'Relaxation') and assessment periods at baseline, posttreatment, and 6-month follow-up. The RCT was conducted following the "Consolidated Standards of Reporting Trials" (CONSORT) guidelines (Schulz et al., 2010).

### 2.2. Recruitment and inclusion criteria

Participants were recruited from two Spanish universities in the province of Zaragoza (Spain). They were students of the University of Zaragoza or the National Distance Education University (UNED). The following were inclusion criteria: (a) ≥ 18 years of age; (b) enrolled in undergraduate or master's degree course; (c) enrolled in the faculties of social sciences or health sciences at the Zaragoza campus (in the case of University of Zaragoza students) or at the Calatayud campus (in the case of UNED students); (d) ability to speak and write in the Spanish language; and (e) providing written informed consent before knowing the assignment group. No exclusion criteria were considered to frame the work as a universal intervention for the promotion of health and stress management in university students (De Vibe et al., 2013; Gallego et al., 2014).

The sample size was estimated taking as a reference a moderate difference ($d$ = 0.40) between the total MBP group and the active control group in the primary variable of perceived stress (Perceived Stress Scale; PSS), as has been observed in previous similar studies (McConville et al., 2017), accepting an alpha of .05 and a beta risk of .20 in a bilateral contrast, with a 2:1 allocation rate (so that two participants were assigned to the mindfulness total group—one in the condition of VR support and another in the condition that does not have such support—for each control subject). This unequal randomization ratio design was established to gain additional exploratory information on the use of VR when added to the MBP (Hey & Kimmelman, 2014; Peckham et al., 2015). Therefore,

and under these circumstances, 225 participants were required: 75 participants in the active control group of relaxation therapy and 150 participants in the total MBP group. Taking into account all participants and assuming an attrition rate of approximately 25% (Nam & Toneatto, 2016), the total sample comprised 280 university students.

### 2.3. Procedure and ethics

Between November 2017 and January 2018, students were recruited through the following main procedures: (1) informative posters were put up in university buildings containing a brief explanation of the study and contact details; (2) several members of the university teaching staff contacted their corresponding students and sent them an informative e-mail with a brief explanation of the study and contact details; (3) different academies, tuition centres, student organizations and support services for university students (e.g., Youth Information and Counselling Center) put ads in their newsletters and Facebook pages with a brief explanation of the study and contact details.

Assignation of the subjects was performed after the baseline evaluation by a member of the research group, who had no knowledge about the study aims and was not involved in the study in any other way, through a simple randomization sequence generated by computer. Participants were randomized into one of three groups ('MBP', 'MBP+VR', or 'Relaxation'), considering the secondary aim of evaluating the potentially different adherence to the programme of each group. The interventions were conducted in two cohorts: cohort 1 started in November 2018 and cohort 2 in April 2019 (Figure 1). Posttreatment and 6-month follow-up measurements were recorded by a different and independent assessor who was blinded to the study condition of participants. Due to the characteristics of the intervention, providers and participants were able to know what kind of intervention they were offering and receiving, respectively, so this was a single-blind study, although all participants were treated through suitable active conditions.

*FIGURE 1*

Written informed consent was obtained from all individual participants included in the study before randomization. They were provided with detailed information about the study and informed that they could leave the study at any time. This study was approved by the ethical committee of Aragon, Spain (registry: PI18/325; November 21st, 2018). All procedures performed in this study involving human participants were in accordance with the criteria of the 1964 Declaration of Helsinki and comparable ethical

standards. The data were treated anonymously and were only used for the purposes of the study. The confidentiality of participants was guaranteed before, during and after the trial and was protected by the Spanish Organic Law on Protection of Personal Data and Guarantee of Digital Rights (3/2018 of December 7, LOPD-GDD) and all relevant EU legislation on privacy and data protection. All study information was confined in secure drawers with limited access. Electronic data files were password-protected and secured via advanced encryption standard (AES-256). This trial was performed in compliance with the study protocol (trial registration: ClinicalTrials.gov NCT03771300, December 11th, 2018), as well as with good clinical practice guidelines with the primary aim of protecting and preserving human rights (Vijayananthan & Nawawi, 2008).

## 2.4. Interventions

Within the three conditions described below, motivational techniques were used to increase adherence of participants to sessions and daily tasks: they were sent reminders via WhatsApp of the start time of the session a few hours prior to each session. Daily tasks aids, such as mindfulness or relaxation exercise audio recordings (depending on the condition), were also sent through a weekly WhatsApp message in each group of treatment. All participants were encouraged to do a daily task at home.

### *2.4.1 Mindfulness-based programme (MBP)*

The protocol used in this study was an adaptation of a MBP that proved efficacy for reducing generalized anxiety disorder symptomatology (Navarro-Haro et al., 2019), which in turn was inspired in the guidelines developed by García-Campayo & Demarzo (2015). The intervention consisted of 90-minute group sessions with 15 or 16 participants per subgroup held once a week over a space of 6 weeks and was offered as an extra-curricular activity. It was structured around two central elements: mindfulness and self-compassion. Mindfulness was introduced in the first session and practiced during the entire programme, while the concept of self-compassion was presented in the fourth session and, since then, the mindfulness exercises incorporated the self-compassionate touch.

The sessions combined components of theory and practice, using a methodology that prioritized inquiry, reflection, and debate among the group of participants. The theory component comprised mindfulness and self-compassion concepts set out over the length of the programme, in addition to others related to time management, stress, anxiety and

the balance between personal life and academic/work life. The practical component of the programme consisted of formal and informal mindfulness and self-compassion exercises under the guidance of a clinical psychologist, who was specifically trained and experienced in application of the theoretical and practical components of the MBP to university students.

Some adaptations of the original protocol were performed in order to meet the undergraduates' profile; firstly, the number of sessions was reduced from seven to six to adjust it to the students' exam period (i.e., the initial 4 sessions of mindfulness presentation and practice were reduced to 3); secondly, the language used to explain some concepts was adapted to get closer to the usual way young people express themselves; finally, one session was dedicated to applying mindfulness and self-compassion to the common challenges of university life, that is, students had to try to recognise and manage their own critical voice, especially the one related to the academic context (e.g. time management, examination, high workload, stress management, etc.). This last adaptation was performed considering the topics introduced in other studies carried out with university students (Kuhlmann et al., 2016; Lynch et al., 2018). Table 1 provides a summary overview of the structure and contents of the MBP session by session.

### *2.4.2. Mindfulness-based programme complemented by VR environments (MBP+VR)*

This condition was equivalent to the previous one (group sessions with 15 or 16 participants, held once a week over a space of 6 weeks and offered as an extra-curricular activity), except the duration of each session, which was reduced from 90 to 75 minutes. Consequently, the content of each mindfulness session was slightly shortened, but this time difference was replaced by an individual VR session held before or after the group mindfulness session. This short VR session was applied on an individual basis and consisted of a mindfulness or self-compassion exercise through VR, including a voice over that guided the meditation; all the virtual scenarios had been designed by PSIOUS® and they had been applied for both research and therapeutic aims in different institutions previously (Torres, 2018; Torres et al., 2017). The VR kit comprised a set of Samsung GEAR VR goggles, a Samsung Galaxy S6 phone and optional headphones (https://www.psious.com/). The content and objectives of each VR module are specified in Table 1, and a screenshot of each VR scenario can be seen in the Supplementary Material S1. In this condition, the mindfulness instructor was the same, but the implementation of VR exercises was performed by another clinical psychologist who was

specifically trained in the application of VR scenarios. Prior to the use of VR, the psychologist checked the participants' general health (e.g., epilepsy, vertigo, or serious mental illness) to avoid potentially harmful effects related to VR application. The participants were seated on a chair in a quiet and secure place.

#### *2.4.3. Relaxation therapy*

This active control intervention was an adapted version proposed by Bernstein and Borkovec of progressive muscle relaxation therapy (Bernstein & Borkovec, 1973). It also consisted of 90-minute group sessions of 15 or 16 participants, held once a week over a space of 6 weeks and was offered as an extra-curricular activity. The relaxation programme involved the training of 16 muscle groups during the initial sessions, 7 muscle groups during the intermediate sessions, 4 muscle groups in the later stage, and only relaxation through recall in the final session. This programme was also complemented with visualizations, as originally proposed by Jacobson (Jacobson, 1938). Table 1 provides a summary of the programme structure and contents. All participants in this condition were instructed by a clinical psychologist specifically trained and experienced in the application of progressive muscle relaxation therapy.

*TABLE 1*

### 2.5. Measures

Demographic information was collected at baseline, including sex, age, nationality, relationships (no relationships, stable relationship), study area (health, social), course, educational level (undergraduate, taught master), and employment status (employed, unemployed). Along with this questionnaire, participants completed the aspects described below as part of a paper-and-pencil battery of measures.

#### *2.5.1. Primary outcome measure*

The Perceived Stress Scale (PSS; Cohen et al. 1983) was the primary outcome measure. It is a 10-item self-reported questionnaire in which participants are asked to rate how unpredictable, uncontrollable and overloaded they have found their life over the past month on a 5-point Likert-type scale (from 0 = 'never' to 4 = 'very often'). Higher scores indicate higher levels of stress. The Spanish PSS (Remor, 2006) provides a reliable and valid measure of perceived stress, with adequate psychometric properties (test-retest, $r$ = .77). Cronbach's alpha showed good-to-excellent internal consistency values in our

sample in every assessment time point (baseline: $\alpha$ = .89; posttreatment: $\alpha$ = .92; follow-up: $\alpha$ = .91).

### *2.5.2. Secondary outcome measures*

The State-Trait Anxiety Inventory (STAI; Spielberger and Gorsuch 1983) is a widely used, validated measure of anxiety that consists of 20 statements that evaluate how participants feel at the present moment (state anxiety) and 20 statements that evaluate how the participants feel in general (trait anxiety). It uses a 0–3 Likert-type rating scale with higher scores indicating greater anxiety levels with good psychometric properties in university students (Fonseca-Pedrero et al., 2012). Cronbach's alphas showed excellent internal consistency in our sample in every assessment time point (baseline: $\alpha$ = .91 and .95; posttreatment: $\alpha$ = .91 and .94; follow-up: $\alpha$ = .91 and .95, respectively).

The Positive and Negative Affect Schedule (PANAS; Watson et al. 1988) is a self-report questionnaire consisting of two 10-item scales to measure both positive and negative affectivity. Each item is rated on a 5-point Likert-type scale from 1 ('not at all') to 5 ('very much'). Scores for each subscale are totalled, with higher scores indicating more positive or negative affect. The psychometric properties of the Spanish version of the PANAS scales have been shown as appropriate (Sandín et al., 1999). Cronbach's alphas showed good-to-excellent internal consistency in our sample in every assessment time point (baseline: $\alpha$ = .88 and .90; posttreatment: $\alpha$ = .86 and .92; follow-up: $\alpha$ = .88 and .91, respectively). In the present study, the PANAS-balance score was used to enhance testing's parsimony. This index is calculated by subtracting the negative affect scores from the positive affect scores of the PANAS (Koydemir & Schütz, 2012).

The Utrecht Work Engagement Survey Scale-Students (UWES-S; Schaufeli et al. 2002) is a 17-item questionnaire measuring academic engagement that includes three subscales: vigour (6 items), dedication (5 items) and absorption (6 items). The UWES-S is scored on a seven-point frequency Likert-type rating scale varying from 0 ('never') to 6 ('always'). In the present study, total scores were calculated with higher scores indicating greater levels of student engagement. The UWES-S Spanish version has been demonstrated to have good psychometric properties (Schaufeli et al., 2002). Cronbach's alpha showed good-to-excellent internal consistency values in our sample in every assessment time point (baseline: $\alpha$ = .89; posttreatment: $\alpha$ = .91; follow-up: $\alpha$ = .91).

The Maslach Burnout Inventory-Student Survey (MBI-SS; Schaufeli et al. 2002) measures burnout symptoms and changes the references to work for references to study. This 15-item questionnaire includes three subscales: exhaustion (5 items), cynicism (4 items) and efficacy (6 items). High scores in exhaustion and cynicism and low scores in efficacy are indicative of burnout. Participants must respond on a Likert-type scale with 7 options ranging from 0 ('never') to 6 ('always'). In the present study, total scores were calculated by summing the item scores (after reversing the corresponding efficacy items). Higher scores indicate greater levels of student burnout. The psychometric properties of the MBI-SS Spanish validation have been observed to be adequate (Schaufeli et al., 2002). Cronbach's alpha values showed good internal consistency in our sample (baseline: $\alpha$ = .85; posttreatment: $\alpha$ = .86; follow-up: $\alpha$ = .88).

The Emotional Regulation Questionnaire (ERQ; Gross and John 2003) is a 10-item scale designed to measure respondents' tendency to regulate their emotions in two ways: cognitive reappraisal (6 items) and expressive suppression (4 items). Participants respond using a 7-point Likert scale (from 1 = 'strongly disagree', to 7 = 'strongly agree') where higher scores indicate increased use of regulatory strategies. The ERQ Spanish version has shown adequate test-retest reliability, and convergent-discriminant validity (Cabello et al., 2013). Cronbach's alpha showed good internal consistency values in our sample (baseline: $\alpha$ = .83 and .83; posttreatment: $\alpha$ = .80 and .85; follow-up: $\alpha$ = .84 and .84, respectively).

### *2.5.3. Mechanistic measures*

The Five Facet Mindfulness Questionnaire (FFMQ; Baer et al. 2008) is a 39-item self-report that consists of five facets: observing (8 items), describing (8 items), acting with awareness (8 items), non-judging of inner experience (8-items) and non-reactivity to inner experience (7 items). Respondents indicate on a 5-point Likert-type scale the degree to which each item is generally true for them, ranging from 1 ('never or very rarely true') to 5 ('very often or always true'). Higher scores indicate higher levels of mindfulness. The facet scores can be combined to produce a total mindfulness score. The Spanish version of this scale has demonstrated good psychometric properties (Cebolla et al., 2012). Cronbach's alpha showed excellent internal consistency values in our sample in every assessment time point (baseline: $\alpha$ = .90; posttreatment: $\alpha$ = .92; follow-up: $\alpha$ = .91).

The Self-Compassion Scale (SCS; Neff 2003) is a 26-item questionnaire that assesses self-compassion across three facets: self-kindness, common humanity and mindfulness. The facet scores can be combined to produce a total score (Neff et al. 2019), in which higher scores indicate greater levels of self-compassion. The SCS uses a 5-point Likert-type scale, ranging from 1 ('almost never') to 5 ('almost always'). The SCS Spanish version has demonstrated to be a valid and reliable instrument (Garcia-Campayo et al., 2014). Cronbach's alpha showed excellent internal consistency values in our sample in every assessment time point (baseline: $\alpha$ = .93; posttreatment: $\alpha$ = .93; follow-up: $\alpha$ = .92).

### 2.6. Data analyses

Socio-demographic data were described at baseline by means of frequencies (percentages) or means (SD), depending on the distribution of each variable. A visual inspection and the corresponding Chi-squared or one-way ANOVA tests were conducted to ascertain the equal distribution of socio-demographics among groups at baseline.

First, efficacy of the MBPs compared to the relaxation control condition was analysed according to the main PSS variable posttreatment (primary endpoint), which was taken as a continuous outcome. It was developed by means of a repeated measures design and an intention to treat (ITT) basis using multilevel mixed-effects linear regression models, including time as an independent variable and subjects and the group of delivery (subgroup) as random effects. The restricted maximum likelihood (REML) estimation was used, which produces unbiased estimates in case of small or unbalanced sample sizes (Egbewale et al., 2014). Non-standardized slopes and 95% confidence intervals (95% CI) were calculated by adjusting the time of the year in which the programme was undertaken (cohort), as well as those socio-demographic variables that showed significant differences between groups at baseline. The 'group x time' interaction was considered in order to study the specific trajectories of each group throughout the intervention and to determine whether the possible between-group differences remained consistent over time. Effect sizes, as the differences between groups at posttreatment and at 6-month follow-up, were assessed using Cohen's *d* statistic, calculated by the combined standard deviation in the baseline, weighing the differences between the corresponding marginal means (Morris, 2008). Effect sizes are usually defined as small when $d \leq 0.2$; medium when $d \geq 0.5$; and large when $d \geq 0.8$ (Cohen 1988).

Secondarily, a per protocol analysis was performed, considering only those participants who attended at least ≥ 50% of the sessions (Gu et al., 2015; Kuyken et al., 2008). Sensitivity analysis were developed to evaluate the possible effect of missing data, which were replaced by multiple imputations based on chained equations as long as there were < 40% missing data in the primary outcome and whether missing values were distributed at random (MAR) to ensure validity (Royston & White, 2015). Imputations were calculated from chained equations using linear regressions that included the main outcome, the baseline covariates included in the model, the mechanistic variables, and those baseline variables that were significantly related to non-response. The efficacy regarding psychological wellbeing, academic functioning, and mechanisms of change was calculated following the same analytical strategy used for the primary analysis. Within-group analyses were also performed for both primary and secondary outcomes. The probability values relative to the main analysis (PSS at posttreatment) were adjusted according to Benjamini-Hochberg's correction for multiple comparisons; secondary analyses were considered as exploratory and thus were not corrected (Feise, 2002).

The reliable change index (RCI) was calculated to determine the proportion of reliable improvements and deteriorations in each group, following the methods stablished by Evans et al. (1998). In addition, a dose-response analysis was conducted using the mixed regression model of the primary analysis at the primary endpoint, with subjects and the group of delivery as random effects adjusted by the time of year in which the programme was undertaken (cohort), as well as those sociodemographic factors that showed significant differences at baseline to examine the effect of treatment adherence (independent variable) under two considerations: a) number of sessions attended and b) completing the intervention (i.e., attending to at least 50% of the sessions; Hölzel et al., 2011; Kuyken et al., 2008).

We also examined whether the baseline to follow-up change of the mindfulness interventions (vs. 'Relaxation') on the primary outcome (PSS) was mediated through baseline-posttreatment changes in the process variables of mindfulness (FFMQ) and self-compassion (SCS). Because the study was not primarily powered to analyse pathways of change, both 'MBP' and 'MBP+VR' were merged into one mindfulness group ('MBPs'), assuming that the potential role of the mechanisms considered here would be similar in both arms. Using path analysis, we explored the direct and indirect associations between the independent variable of treatment condition ('MBPs' vs. 'Relaxation'), baseline-

posttreatment changes in trait mindfulness (FFMQ) and self-compassion (SCS) as potential multiple mediators that were introduced simultaneously in parallel in the model, with baseline to follow-up changes in perceived stress (PSS) as the dependent variable. Therefore, the direct path between the treatment condition and the primary outcome, and the indirect effect paths through mindfulness and self-compassion in parallel were tested. For that, only participants with no missing data were included (complete cases analysis). Regression coefficients (*B*) of bias-corrected indirect effects were calculated, as well as their standard errors, which were based on 10,000 bootstrap samples. The indirect effects were considered significant when their corresponding 95% *CI* did not cross zero (Lockhart et al., 2011).

Finally, the possible impact of VR exposure on treatment adherence was explored comparing a) the number of sessions attended in the three study arms, using the Kruskal-Wallis and Mann-Whitney tests and b) the percentage of participants who completed the intervention (i.e., attended at least 50% of the sessions) using Fisher's test.

An alpha level of .05 was set, using a two-tailed test. Data analyses were computed using STATA v12.0, Mplus v8.4, and IBM SPSS v26.0 statistical software.

## 3. Results

### 3.1. Participant flow and compliance

We randomly assigned 280 students to the 'MBP' (*n* = 93), 'MBP+VR' (*n* = 93), or 'Relaxation' (*n* = 94) group. Figure 2 shows the flowchart and compliance of participants in the RCT; two (2.1%) people in the 'MBP+VR' group and eight (8.5%) in the 'Relaxation' condition, withdrew from the study before starting the intervention without attending any session. At posttreatment assessment, 74 (79.6%) participants in the 'MBP' group, 89 (95.7%) in the 'MBP+VR' group, and 61 (65.6%) in the 'relaxation' group provided outcome data. The retention rates at follow-up assessment were 65 (69.3%), 70 (75.3%), and 53 (56.4%), respectively. Interestingly, irrespective of the group, students who performed the intervention in cohort 2 dropped out significantly more both at posttreatment and follow-up compared to those who were in cohort 1. Supplementary Material S2 shows the baseline variables predicting missing primary outcome data at posttreatment and follow-up time points.

*FIGURE 2*

### 3.2. Baseline sociodemographic and clinical characteristics

The sample was composed mostly by women (*n* = 221; 78.9%), with a mean age of 22.25 years old (*SD* = 5.75). Most participants were Spanish (*n* = 269, 96.1%), single (*n* = 156, 55.7%) and unemployed (*n* = 222, 79.3%). The majority of participants were studying a health-related degree (*n* = 205, 73.2%), such as nursing, medicine, physiotherapy or psychology. Most of them were in the first 3 courses of the degree (*n* = 230, 82.1%), and only 10 (3.6%) were studying for a master's. Baseline characteristics were similar in most cases between groups (Table 2). However, significant differences were observed between the 3 study conditions in terms of employment status ($\chi^2$ (1) = 7.62; *p* = .022) and thus, it was included as a covariate in the regression models.

*TABLE 2*

With respect to clinical baseline characteristics, Supplementary Material S3 presents the raw descriptive statistics for primary and secondary outcomes, where no statistically significant differences were observed between groups (all *p*-values > .05).

### 3.3. Effects on the primary outcome

Two-hundred and twenty-four (80%) participants completed the primary outcome (perceived stress) at the primary endpoint (posttreatment). After adjusting for our set of covariates (cohort and employment status), 'MBP' (*B* = -2.77; *p* = .006) and 'MBP+VR' (*B* = -2.44; *p* = .014) significantly reduced perceived stress posttreatment compared to 'Relaxation' therapy (differences remained significant after correcting for multiple comparisons). These differences were of a moderate to large effect size: *d* = -0.72 in the case of 'MBP', and *d* = -0.59 in the case of 'MBP+VR'.

Per-protocol analyses, including only those participants who completed at least half of the training (≥ 3 sessions in each group) yielded very similar results: 'Relaxation' vs 'MBP' (*B* = -2.84; *p* = .012) and 'Relaxation' vs 'MBP+VR' (*B* = -2.48; *p* = .023). When analysing imputed values, again, similar results were observed: 'Relaxation' vs 'MBP' (*B* = -3.21; *p* < .001) 'Relaxation' vs 'MBP+VR' (*B* = -2.20; *p* < .001).

At 6-month follow-up, 'MBP' and 'MBP+VR' groups showed reduced scores compared to the 'Relaxation' condition in perceived stress (Table 3). The 'MBP' group presented a significant reduction in perceived stress at follow-up compared to 'Relaxation' (*B* = -2.98; *p* = .014), with a moderate effect size (*d* = -0.75). On the other

hand, ‘MBP+VR’ significantly reduced perceived stress at follow-up compared to the ‘Relaxation’ condition ($B$ = -3.64; $p$ = .003), with a large effect size ($d$ = -0.87).

*TABLE 3*

With respect to the primary outcome within group analyses, results showed that perceived stress in the ‘MBP’ and ‘MBP+VR’ groups experienced significant reductions both at posttreatment and follow-up compared to baseline ($p$-values < .001), whereas participants receiving ‘Relaxation’ only showed significantly lower scores at posttreatment ($p$ = .028). See Supplementary Material S4 for detailed information on within group analyses.

The RCI for the main outcome was a change in raw score of 3.53 points or more in either direction (PSS). That implied that 41 participants (46.1%) in the ‘MBP+VR’ group experienced a reliable improvement, whereas 13 (14.6%) experienced reliable deterioration. In the ‘MBP’ group, 38 (51.4%) improved reliably and only 6 (8.1%) reported reliable deterioration. Finally, among those who participated in the ‘Relaxation’ intervention, 19 (31.1%) reported a reliable improvement, while 13 (21.3%) experienced a reliable deterioration. These differences were not statistically significant ($\chi^2$ = 8.03, $p$ = .091).

### 3.4. Dose-response analyses

The dose-response analyses (Table 4) showed additional benefits on perceived stress in the ‘MBP’ and ‘MBP+VR’ groups, both with more individual sessions attended and when attending ≥ 50% of the sessions (i.e., ≥ 3 sessions). However, there were not dose-response effects observed in the ‘Relaxation’ group.

*TABLE 4*

### 3.5. Mediation analysis: the role of mindfulness and self-compassion

Results from parallel mediation analysis indicated that treatment using mindfulness techniques (‘MBPs’ vs. ‘Relaxation’) was indirectly related to baseline to follow-up improvements in the primary outcome of perceived stress (PSS) through its baseline-posttreatment effects in mindfulness (FFMQ) and self-compassion (SCS). As shown in Figure 2, those students who received ‘MBP’ interventions reported higher baseline-posttreatment improvements in FFMQ ($a_1$ = 8.08, $p$ = .017), and SCS ($a_2$ = 8.70, $p$ = .003), and higher baseline-posttreatment FFMQ ($b_1$ = -0.14, $p$ = .008) and SCS ($b_2$ =

-0.13, $p$ = .027) improvements were subsequently related to greater baseline to follow-up reductions in perceived stress. A 95% bias-corrected *CI* based on 10,000 bootstrap samples indicated the indirect effects through FFMQ (a1×b1 = -1.09) and SCS (a2×b2 = -1.14) were entirely above zero (-2.20 to -0.24 and -2.45 to -0.09, respectively). There were no significant differences between indirect effects of FFMQ and SCS (diff = 0.05, 95% bias-corrected CI = -1.59 to 1.67). There was no evidence that the use of mindfulness techniques or 'Relaxation' influenced the change in perceived stress independent of its effects on FFMQ and SCS ($c'$ = -0.80, $p$ = .612).

*FIGURE 3*

### 3.6. Effects on secondary outcomes

'MBP' compared to 'Relaxation' showed significant improvements at posttreatment in STAI-trait ($B$ = -3.36; $p$ = .007, $d$ = -0.95), ERQ-suppression ($B$ = -1.58; $p$ = .008, $d$ = -0.71), FFMQ ($B$ = 9.19; $p$ < .001, $d$ = 1.01), and SCS ($B$ = 8.84; $p$ < .001, $d$ = 1.10). At follow-up, these effects remained significant with similar effect sizes, and significant effects were also found for STAI-State ($B$ = -7.74; $p$ < .001, $d$ = -1.37), PANAS-balance ($B$ = 5.64; $p$ < .001, $d$ = 1.02), UWES ($B$ = 6.35; $p$ < .001, $d$ = 1.14), MBI-SS ($B$ = -7.59; $p$ < .001, $d$ = -1.60), and ERQ-reappraisal ($B$ = 2.32; $p$ = .029, $d$ = 0.65).

'MBP+VR' compared to 'Relaxation' showed significant improvements at posttreatment in PANAS-balance ($B$ = 3.13; $p$ = .032, $d$ = 0.54), UWES ($B$ = 3.50; $p$ = .015, $d$ = 0.60), ERQ-suppression ($B$ = -1.17; $p$ = .047, $d$ = -0.50), FFMQ ($B$ = 7.18; $p$ = .005, $d$ = 0.72), and SCS ($B$ = 7.93; $p$ < .001, $d$ = 0.94). At follow-up, significant effects were found for STAI-trait ($B$ = -4.24; $p$ = .007, $d$ = -1.41), STAI-state ($B$ = -6.42; $p$ < .0001, $d$ = -1.08), PANAS-balance ($B$ = 5.98; $p$ < .001, $d$ = 1.03), MBI ($B$ = -3.88; $p$ = .016, $d$ = -0.77), FFMQ ($B$ = 12.46; $p$ < .001, $d$ = 1.24), and SCS ($B$ = 12.42; $p$ < .001, $d$ = 1.47).

The comparison between the two mindfulness conditions ('MBP' and 'MBP+VR') only showed one significant effect on MBI-SS at follow-up ($B$ = -3.72; $p$ = .024) of moderate effect size ($d$ = -0.71), favouring 'MBP' (Table 3).

The within group analyses showed that the 'MBP' and 'MBP+VR' groups experienced significant improvements in all the secondary outcomes, except for ERQ-

reappraisal at posttreatment in the case of 'MBP+VR', which showed a trend, with $p$ = .060 at both posttreatment and follow-up compared to baseline, while 'Relaxation' only achieved significant effects on STAI-state, PANAS-balance, FFMQ and SCS at posttreatment and ERQ-suppression, FFMQ and SCS at follow-up. These results are detailed in the Supplementary Material S4.

### 3.7. Impact of VR on treatment adherence

The median number of sessions attended in the 'MBP' group was 4 (interquartile range = 3 to 5), while it was of 5 (interquartile range = 4 to 6) in 'MBP+VR' and 3 (interquartile range = 1 to 5) in the 'Relaxation' group. There were significant differences between groups in terms of the number of sessions attended: 'MBP+VR' showed more adherence than either 'MBP' or 'Relaxation' ($p$ < .001), and 'MBP' presented a significantly higher mean number of sessions attended than the 'Relaxation' group ($p$ < .001). 'MBP+VR' had a significantly higher number of participants who attended 3 or more sessions (see Figure 2): 89 (95.7%), compared to 77 (82.8%) in the 'MBP' group, and 66 (70.2%) in the 'Relaxation' group (Fisher $p$ < .001). Specifically, the 'MBP+VR' group retained significantly more completers than the 'MBP' group ($p$ = .005) and the 'Relaxation' condition ($p$ < .001).

## 4. Discussion

This RCT aimed to assess the efficacy of mindfulness training compared to relaxation therapy for reducing perceived stress in a sample of Spanish undergraduates, as well as examining the potential mediational effect of mindfulness and self-compassion on the long-term effects of mindfulness training on perceived stress, and to explore whether the inclusion of VR exposure enhances the adherence to mindfulness training.

Results indicate that the three interventions ('MBP', 'MBP+VR', and 'Relaxation') produced a significant decrease in levels of perceived stress in our sample, which was notable at baseline and comparable to results reported in previous studies (Enns et al., 2018; Shaw et al., 2017). Nonetheless, MBPs' impact on this outcome was significantly stronger than that observed in the relaxation group, with moderate effect sizes posttreatment and moderate-to-large effect sizes long term. Some previous studies, such as Jain et al. (2007), did not identify differential efficacy when comparing a mindfulness programme and a relaxation-based intervention for reducing perceived stress, although the first produced a significant reduction in ruminative thoughts and

distractions; on the other hand, several studies have reported that MBPs produce significant reductions on perceived stress when compared to inactive control groups (Cavanagh et al., 2013; Erogul et al., 2014; Greeson et al., 2014; Hazlett-Stevens & Oren, 2017; Keng et al., 2015; Warnecke et al., 2011).

Regarding maintenance of the effect produced by MBPs on perceived stress in the long term, many studies have reported loss of significance in their follow-ups, even when using inactive control groups (Erogul et al., 2014; Kuhlmann et al., 2016; Phang et al., 2015; Warnecke et al., 2011); some authors hypothesize that home practice plays a key role in maintaining the improvement achieved once the intervention is over (McConville et al., 2017). There is consistent evidence supporting the link between home practice and MBPs' outcomes (Parsons et al., 2017), and it has even been considered that some of these outcomes, including perceived stress, may be particularly practice-dependent in clinical conditions, such as fibromyalgia (Pérez-Aranda et al., 2019), meaning that stopping practicing could imply a loss of the effect previously achieved. However, the present study did not assess the frequency of home practice of mindfulness exercises once the programme was finished, and thus this hypothesis could not be tested. Nevertheless, the dose-response analyses support this assumption, as the number of sessions attended, which is implicitly associated with practice, had a significant impact on the effect of 'MBP' and 'MBP+VR' on the main outcome perceived stress.

MBPs also resulted in significant improvements compared to relaxation in anxiety-trait, affectivity balance, academic engagement, emotional regulation (expressive suppression), mindfulness, and self-compassion in the posttreatment assessment, with moderate-to-large effect sizes; as well as in all the outcomes at the 6-month follow-up with moderate-to-large effect sizes. According to our results, the superiority of MBPs compared to relaxation could be due in part to a relatively small impact of this latter on the outcomes, which was not significant in some cases (e.g., academic engagement, burnout, and emotion regulation at posttreatment; perceived stress, anxiety, affectivity balance, academic engagement, burnout, or emotion regulation in the follow-up). The empirical evidence published to date is not totally homogeneous in this regard but seems to indicate that MBPs produce significant effects on outcomes, such as anxiety, positive affect, or emotional regulation, compared to inactive control groups (Delgado-Pastor et al., 2015; Dundas et al., 2017; Halladay et al., 2019; McConville et al., 2017) but not when compared to active control conditions (Delgado-Pastor et al., 2015; Delgado et al.,

2010; Halladay et al., 2019; Walsh, 2011). The effect of mindfulness programmes on other outcomes, such as burnout or academic engagement, has not been widely examined, hindering comparisons between studies.

On the other hand, significant improvements produced by MBPs on mindfulness and self-compassion have been previously reported, both when comparing them to active control groups (Falsafi, 2016; McIndoo et al., 2016) and to inactive control groups (Cavanagh et al. 2013; Erogul et al. 2014; Greeson et al. 2014; Gu et al. 2018; Keng et al. 2015; Lever Taylor et al. 2014; Phang et al. 2015; Song and Lindquist 2015). The nuclear role of mindfulness and self-compassion in MBPs was confirmed in our study by means of a path analysis in which both variables mediated the long-term effect of MBPs on perceived stress. These findings imply that MBPs produce significant changes in mindfulness and self-compassion, which could in turn be responsible for the long-term reduction in perceived stress. Previous studies have found similar results, such as Hindman et al. (2015), who found that increases in one facet of mindfulness (non-reactivity to inner experience) and self-compassion, next to decreases in worry, mediated the effect of an MBP on university students' stress. Studies conducted on other populations have also found these variables to be significant mediators of MBPs' effect on stress. This was the case of Pérez-Aranda et al. (2019), who reported the mindfulness facet 'Acting with awareness' to mediate an MBP's effect on perceived stress on a sample of people with fibromyalgia, along with psychological flexibility, another core construct of 'third-wave' psychotherapies, which is strongly associated with self-compassion and is defined as the ability to act effectively in accordance with a valued life in the presence of unpleasant thoughts, emotions or bodily symptoms (Hayes et al., 1999).

Finally, this study aimed to explore the potential impact of adding VR exposure to a mindfulness programme in terms of treatment adherence. Our results indicate that 'MBP+VR' registered higher attendance to sessions and retained significantly more participants than 'MBP' alone: 95.7% in the 'MBP+VR' group attended at least half of the programme, compared to 82.8% in the 'MBP' group. These adherence rates are higher than those reported in most previous studies (Khoury et al., 2013; Nam & Toneatto, 2016), which might be due in part to the great motivation towards practicing mindfulness that our sample of voluntary undergraduates seemed to present. However, it needs to be reminded that brief psychotherapies, also those which include mindfulness, have often presented high attrition rates among university students (Khoury et al., 2013; Nam &

Toneatto, 2016; Pedrelli et al., 2015; Richards & Borglin, 2011), and the VR ingredient could play a key role for overcoming this limitation. Previous research had already suggested that including VR exposure could have a positive impact on treatment adherence (Botella et al., 2013; Gebara et al., 2016; Gregg & Tarrier, 2007; Navarro-Haro et al., 2019; Wiederhold et al., 2016). However, the two interventions did not significantly differ in terms of efficacy; this could be due to different reasons, such as 1) the VR exposure could be limiting the MBP's efficacy for those individuals who already present high adherence rates, which would imply the need of including VR exposure only for groups who present low adherence to the intervention; and 2) the MBP would show efficacy for reducing perceived stress in undergraduates as long as the adherence rates are sufficient, regardless of the inclusion of VR exposure; this would be an ingredient that would not imply any significant difference in terms of the effect of the intervention, but could be used for increasing treatment adherence. In any case, further studies are needed to replicate our results and test these hypotheses regarding the differential role of adding VR exposure to MBPs. On the other hand, the relaxation programme presented significant rates of dropout compared to the MBPs, and a notable part of the participants reported 'no utility' of the intervention as the reason for discontinuing. Very important and little considered in previous studies is the moment of the academic year that favours greater adherence to the programme. In our case, we found results in favour of an implementation during the first four months of the course.

### *Limitations*

Some limitations of this study need to be acknowledged. First, the sample of this study consists of voluntary university students, who may possibly present higher levels of motivation or commitment towards the interventions. Especially in the case of those students of health sciences, this could be associated to having previous knowledge about mindfulness, but this was not assessed and therefore could not be included in subsequent analyses. In addition, the participants knew the study arm they were assigned, which may have affected their expectancies. Second, the sample was mostly comprised of females, students of health-related degrees and from only one city (Zaragoza, Spain), which implies that our results should not be considered representative of the whole Spanish undergraduate population. Furthermore, the assessment was conducted using self-reported measures, which could introduce some bias, and the present study did not include symptom measures of depressive and anxiety disorders, nor stress-related physical

symptoms measures; future studies should take these outcomes in consideration, in view of the high rates of psychological disorders among university students (Auerbach et al., 2018). In addition, the comparison between 'MBP' and 'MBP+VR' groups should be considered as exploratory due to the lack of statistical power for these analyses. Finally, the present study did not assess the potential harmful effects of the interventions, and the proportion of reliable deteriorations, which was relatively high but within the expected values for MBPs and psychotherapy in general (Baer et al., 2020), could indicate that some participants in the 3 groups could have experienced adverse effects; in addition, our study did not register the frequency of mindfulness practice during the intervention or in the follow-up period; therefore, the hypothesis regarding the impact of home practice on the maintenance of the improvements could not be tested.

## Conclusions

In this RCT, mindfulness training has proven to be more efficacious than relaxation for reducing perceived stress and other psychological and academic-related outcomes (e.g., anxiety, emotion regulation, academic engagement, and burnout) in a sample of Spanish university students postintervention and at the 6-month follow-up, with moderate-to-large effect sizes. The inclusion of VR exposure resulted in an improved adherence to the mindfulness programme, although it did not affect the efficacy of the intervention. These results need to be replicated in further studies before considering VR exposure as a solid addition for mindfulness-based interventions; it will be particularly interesting to test the added value of VR in different samples including older populations, as the use of new technologies might not have the same adherence-booster effect that has shown for undergraduates. In the same line, it needs to be tested if, as abovementioned, MBPs which already present sufficient adherence rates would benefit from adding VR exposure or if, on the contrary, this ingredient would only be recommendable for those individuals who show low adherence to the intervention. Also, future research should analyse the cost-utility of these interventions, as they require using some devices which–with some exceptions–are expensive, but the potential health benefits could make the investment worthy in economic terms, via the reduction of direct costs derived from stress and other psychopathological symptomatology. The present work also observed that mindfulness and self-compassion were significant mediators of the long-term effects of MBPs on perceived stress. Other academic institutions of higher education are

encouraged to introduce different initiatives, such as this one, to help care for students' mental health.

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**Declarations of interest**

The authors declare that they have no competing interests.

**CRediT authorship contribution statement**

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## References


Auerbach, R. P., Mortier, P., Bruffaerts, R., Alonso, J., Benjet, C., Cuijpers, P., Demyttenaere, K., Ebert, D. D., Green, J. G., Hasking, P., Murray, E., Nock, M. K., Pinder-Amaker, S., Sampson, N. A., Stein, D. J., Vilagut, G., Zaslavsky, A. M., & Kessler, R. C. (2018). WHO world mental health surveys international college student project: Prevalence and distribution of mental disorders. *Journal of Abnormal Psychology*, *127*(7), 623–638. DOI: 10.1037/abn0000362

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., Walsh, E., Duggan, D., & Williams, J. M. G. (2008). Construct validity of the five facet mindfulness questionnaire in meditating and nonmeditating samples. *Assessment*, *15*(3), 329–342. DOI: 10.1177/1073191107313003

Baer, R., Crane, C., Montero-Marin, J., Phillips, A., Taylor, L., Tickell, A., & Kuyken, W. (2020). Frequency of Self-reported Unpleasant Events and Harm in a Mindfulness-Based Program in Two General Population Samples. *Mindfulness*, *12*(3), 763–774. DOI: 10.1007/s12671-020-01547-8

Bernstein, D. A., & Borkovec, T. D. (1973). *Progressive Relaxation Training: A Manual for the Helping Professions*. Research Press.

Botella, C., Garcia-Palacios, A., Vizcaíno, Y., Herrero, R., Baños, R. M., & Belmonte, M. A. (2013). Virtual reality in the treatment of fibromyalgia: A pilot study. *Cyberpsychology, Behavior, and Social Networking*, *16*(3), 215–223. DOI: 10.1089/cyber.2012.1572

Caballero, C. C., & Breso, E. (2015). Burnout in university students. *Psicología Desde El Caribe*, *32*(3), 89–108. DOI: 10.14482/psdc.32.3.6217

Cabello, R., Salguero, J. M., Fernández-Berrocal, P., & Gross, J. J. (2013). A Spanish adaptation of the Emotion Regulation Questionnaire. *European Journal of Psychological Assessment*, *29*(4), 234–240. DOI: 10.1027/1015-5759/a000150

Carl, E., Stein, A. T., Levihn-Coon, A., Pogue, J. R., Rothbaum, B., Emmelkamp, P., Asmundson, G. J. G., Carlbring, P., & Powers, M. B. (2019). Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled trials. *Journal of Anxiety Disorders*, *61*, 27–36. DOI: 10.1016/j.janxdis.2018.08.003

Cavanagh, K., Strauss, C., Cicconi, F., Griffiths, N., Wyper, A., & Jones, F. (2013). A randomised controlled trial of a brief online mindfulness-based intervention. *Behaviour Research and Therapy*, *51*(9), 573–578. DOI: 10.1016/j.brat.2013.06.003

Cebolla, A., García-Palacios, A., Soler, J., Guillen, V., Baños, R., & Botella, C. (2012). Psychometric properties of the Spanish validation of the Five Facets of Mindfulness Questionnaire (FFMQ). *The European Journal of Psychiatry*, *26*(2), 118–126. DOI: 10.4321/S0213-61632012000200005

Chandrasiri, A., Collett, J., Fassbender, E., & De Foe, A. (2020). A virtual reality approach to mindfulness skills training. *Virtual Reality*, *24*(1), 143–149. DOI: 10.1007/s10055-019-00380-2

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Erlbaum Psych

Press.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A Global Measure of Perceived Stress. *Journal of Health and Social Behavior*, *24*(4), 385. DOI: 10.2307/2136404

Conley, C. S., Shapiro, J. B., Kirsch, A. C., & Durlak, J. A. (2017). A meta-analysis of indicated mental health prevention programs for at-risk higher education students. *Journal of Counseling Psychology*, *64*(2), 121–140. DOI: 10.1037/cou0000190

Coo, C., & Salanova, M. (2018). Mindfulness Can Make You Happy-and-Productive: A Mindfulness Controlled Trial and Its Effects on Happiness, Work Engagement and Performance. *Journal of Happiness Studies*, *19*(6), 1691–1711. DOI: 10.1007/s10902-017-9892-8

De Vibe, M., Solhaug, I., Tyssen, R., Friborg, O., Rosenvinge, J. H., Sørlie, T., & Bjørndal, A. (2013). Mindfulness training for stress management: A randomised controlled study of medical and psychology students. *BMC Medical Education*, *13*(1), 107. DOI: 10.1186/1472-6920-13-107

Delgado-Pastor, L. C., Ciria, L. F., Blanca, B., Mata, J. L., Vera, M. N., & Vila, J. (2015). Dissociation between the cognitive and interoceptive components of mindfulness in the treatment of chronic worry. *Journal of Behavior Therapy and Experimental Psychiatry*, *48*, 192–199. DOI: 10.1016/j.jbtep.2015.04.001

Delgado, L. C., Guerra, P., Perakakis, P., Vera, M. N., del Paso, G. R., & Vila, J. (2010). Treating chronic worry: Psychological and physiological effects of a training programme based on mindfulness. *Behaviour Research and Therapy*, *48*(9), 873–882. DOI: 10.1016/j.brat.2010.05.012

Demarzo, M. M. P., Montero-Marin, J., Cuijpers, P., Zabaleta-del-Olmo, E., Mahtani, K. R., Vellinga, A., Vicens, C., López-del-Hoyo, Y., & García-Campayo, J. (2015). The efficacy of mindfulness-based interventions in primary care: A meta-analytic review. *Annals of Family Medicine*, *13*(6), 573–582. DOI: 10.1370/afm.1863

Diemer, J., Mühlberger, A., Pauli, P., & Zwanzger, P. (2014). Virtual reality exposure in anxiety disorders: Impact on psychophysiological reactivity. *World Journal of Biological Psychiatry*, *15*(6), 427–442. DOI: 10.3109/15622975.2014.892632

Dolbier, C. L., & Rush, T. E. (2012). Efficacy of abbreviated progressive muscle relaxation in a high-stress college sample. *International Journal of Stress Management*, *19*(1), 48–68. DOI: 10.1037/a0027326

Dundas, I., Binder, P. E., Hansen, T. G. B., & Stige, S. H. (2017). Does a short self-compassion intervention for students increase healthy self-regulation? A randomized control trial. *Scandinavian Journal of Psychology*, *58*(5), 443–450. DOI: 10.1111/sjop.12385

Dvořáková, K., Kishida, M., Li, J., Elavsky, S., Broderick, P. C., Agrusti, M. R., & Greenberg, M. T. (2017). Promoting healthy transition to college through mindfulness training with first-year college students: Pilot randomized controlled trial. *Journal of American College Health*, *65*(4), 259–267. DOI: 10.1080/07448481.2017.1278605

Dyrbye, L. N., Thomas, M. R., & Shanafelt, T. D. (2006). Systematic review of

depression, anxiety, and other indicators of psychological distress among U.S. and Canadian medical students. *Academic Medicine*, *81*(4), 354–373. DOI: 10.1097/00001888-200604000-00009

Egbewale, B. E., Lewis, M., & Sim, J. (2014). Bias, precision and statistical power of analysis of covariance in the analysis of randomized trials with baseline imbalance: A simulation study. *BMC Medical Research Methodology*, *14*(1), 49. DOI: 10.1186/1471-2288-14-49

Enns, A., Eldridge, G. D., Montgomery, C., & Gonzalez, V. M. (2018). Perceived stress, coping strategies, and emotional intelligence: A cross-sectional study of university students in helping disciplines. *Nurse Education Today*, *68*, 226–231. DOI: 10.1016/j.nedt.2018.06.012

Erogul, M., Singer, G., McIntyre, T., & Stefanov, D. G. (2014). Abridged Mindfulness Intervention to Support Wellness in First-Year Medical Students. *Teaching and Learning in Medicine*, *26*(4), 350–356. DOI: 10.1080/10401334.2014.945025

Evans, C., Margison, F., & Barkham, M. (1998). The contribution of reliable and clinically significant change methods to evidence-based mental health. *Evidence-Based Mental Health*, *1*(3), 70–72. DOI: 10.1136/ebmh.1.3.70

Falsafi, N. (2016). A Randomized Controlled Trial of Mindfulness Versus Yoga: Effects on Depression and/or Anxiety in College Students. *Journal of the American Psychiatric Nurses Association*, *22*(6), 483–497. DOI: 10.1177/1078390316663307

Feise, R. J. (2002). Do multiple outcome measures require p-value adjustment? *BMC Medical Research Methodology*, *2*(1), 1–4. DOI: 10.1186/1471-2288-2-8

Flores, A., Linehan, M. M., Todd, S. R., & Hoffman, H. G. (2018). The use of virtual reality to facilitate Mindfulness skills training in Dialectical behavioral therapy for spinal cord injury: A case study. *Frontiers in Psychology*, *9*(APR), 531. DOI: 10.3389/fpsyg.2018.00531

Fonseca-Pedrero, E., Paino, M., Sierra-Baigrie, S., Lemos-Giráldez, S., & Muñiz, J. (2012). Propiedades Psicométricas del "Cuestionario de Ansiedad Estado-Rasgo" (STAI) en Universitarios. *Behavioral Psychology/ Psicologia Conductual*, *20*(3), 547–561. https://www.behavioralpsycho.com/producto/propiedades-psicometricas-del-cuestionario-de-ansiedad-estado-rasgo-stai-en-universitarios/

Furlong, J., & Davies, C. (2012). Young people, new technologies and learning at home: Taking context seriously. *Oxford Review of Education*, *38*(1), 45–62. DOI: 10.1080/03054985.2011.577944

Galante, J., Dufour, G., Vainre, M., Wagner, A. P., Stochl, J., Benton, A., Lathia, N., Howarth, E., & Jones, P. B. (2018). A mindfulness-based intervention to increase resilience to stress in university students (the Mindful Student Study): a pragmatic randomised controlled trial. *The Lancet Public Health*, *3*(2), e72–e81. DOI: 10.1016/S2468-2667(17)30231-1

Gallego-Gómez, J. I., Balanza, S., Leal-Llopis, J., García-Méndez, J. A., Oliva-Pérez, J., Doménech-Tortosa, J., Gómez-Gallego, M., Simonelli-Muñoz, A. J., & Rivera-Caravaca, J. M. (2020). Effectiveness of music therapy and progressive muscle relaxation in reducing stress before exams and improving academic performance in

Nursing students: A randomized trial. *Nurse Education Today*, *84*, 104217. DOI: 10.1016/j.nedt.2019.104217

Gallego, J., Aguilar-Parra, J. M., Cangas, A. J., Langer, Á. I., & Mañas, I. (2014). Effect of a mindfulness program on stress, anxiety and depression in university students. *Spanish Journal of Psychology*, *17*, 1–6. https://doi.org/10.1017/sjp.2014.102

García-Campayo, J., & Demarzo, M. M. P. (2015). *Mindfulness y compasión: la nueva revolucion*. Siglantana.

Garcia-Campayo, J., Navarro-Gil, M., Andrés, E., Montero-Marin, J., López-Artal, L., & Demarzo, M. M. P. (2014). Validation of the Spanish versions of the long (26 items) and short (12 items) forms of the Self-Compassion Scale (SCS). *Health and Quality of Life Outcomes*, *12*(1), 4. DOI: 10.1186/1477-7525-12-4

Gebara, C. M., de Barros-Neto, T. P., Gertsenchtein, L., & Lotufo-Neto, F. (2016). Virtual reality exposure using three-dimensional images for the treatment of social phobia. *Revista Brasileira de Psiquiatria*, *38*(1), 24–29. DOI: 10.1590/1516-4446-2014-1560

Gomez, J., Hoffman, H. G., Bistricky, S. L., Gonzalez, M., Rosenberg, L., Sampaio, M., Garcia-Palacios, A., Navarro-Haro, M. V., Alhalabi, W., Rosenberg, M., Meyer, W. J., & Linehan, M. M. (2017). The use of virtual reality facilitates dialectical behavior therapy® "observing sounds and visuals" mindfulness skills training exercises for a Latino patient with severe burns: A case study. *Frontiers in Psychology*, *8*(SEP), 1611. DOI: 10.3389/fpsyg.2017.01611

Gotink, R. A., Chu, P., Busschbach, J. J. V., Benson, H., Fricchione, G. L., & Hunink, M. G. M. (2015). Standardised mindfulness-based interventions in healthcare: An overview of systematic reviews and meta-analyses of RCTs. *PLoS ONE*, *10*(4), e0124344. DOI: 10.1371/journal.pone.0124344

Greeson, J. M., Juberg, M. K., Maytan, M., James, K., & Rogers, H. (2014). A randomized controlled trial of Koru: A mindfulness program for college students and other emerging adults. *Journal of American College Health*, *62*(4), 222–233. DOI: 10.1080/07448481.2014.887571

Gregg, L., & Tarrier, N. (2007). Virtual reality in mental health. A review of the literature. *Social Psychiatry and Psychiatric Epidemiology*, *42*(5), 343–354. DOI: 10.1007/s00127-007-0173-4

Gross, J. J., & John, O. P. (2003). Individual Differences in Two Emotion Regulation Processes: Implications for Affect, Relationships, and Well-Being. *Journal of Personality and Social Psychology*, *85*(2), 348–362. DOI: 10.1037/0022-3514.85.2.348

Gu, J., Strauss, C., Bond, R., & Cavanagh, K. (2015). How do mindfulness-based cognitive therapy and mindfulness-based stress reduction improve mental health and wellbeing? A systematic review and meta-analysis of mediation studies. *Clinical Psychology Review*, *37*, 1–12. DOI: http://dx.doi.org/10.1016/j.cpr.2015.01.006

Gu, Y., Xu, G., & Zhu, Y. (2018). A Randomized Controlled Trial of Mindfulness-Based Cognitive Therapy for College Students With ADHD. *Journal of Attention Disorders*, *22*(4), 388–399. DOI: 10.1177/1087054716686183

Halladay, J. E., Dawdy, J. L., McNamara, I. F., Chen, A. J., Vitoroulis, I., McInnes, N., & Munn, C. (2019). Mindfulness for the Mental Health and Well-Being of Post-Secondary Students: A Systematic Review and Meta-Analysis. *Mindfulness*, *10*(3), 397–414. DOI: 10.1007/s12671-018-0979-z

Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (1999). *Acceptance and commitment therapy: An experiential approach to behavior change*. Guilford Press. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:No+Title#0%5Cnhttp://books.google.com/books?hl=en&lr=&id=CTgSzAdxc8cC&pgis=1

Hazlett-Stevens, H., & Oren, Y. (2017). Effectiveness of Mindfulness-Based Stress Reduction Bibliotherapy: A Preliminary Randomized Controlled Trial. *Journal of Clinical Psychology*, *73*(6), 626–637. DOI: 10.1002/jclp.22370

Hey, S. P., & Kimmelman, J. (2014). The questionable use of unequal allocation in confirmatory trials. *Neurology*, *82*(1), 77–79. DOI: 10.1212/01.wnl.0000438226.10353.1c

Hindman, R. K., Glass, C. R., Arnkoff, D. B., & Maron, D. D. (2015). A Comparison of Formal and Informal Mindfulness Programs for Stress Reduction in University Students. *Mindfulness*, *6*(4), 873–884. DOI: 10.1007/s12671-014-0331-1

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. In *Perspectives on Psychological Science* (Vol. 6, Issue 6, pp. 537–559). DOI: 10.1177/1745691611419671

Ibrahim, A. K., Kelly, S. J., Adams, C. E., & Glazebrook, C. (2013). A systematic review of studies of depression prevalence in university students. *Journal of Psychiatric Research*, *47*(3), 391–400. DOI: 10.1016/j.jpsychires.2012.11.015

Ireland, M. J., Clough, B., Gill, K., Langan, F., O'Connor, A., & Spencer, L. (2017). A randomized controlled trial of mindfulness to reduce stress and burnout among intern medical practitioners. *Medical Teacher*, *39*(4), 409–414. DOI: 10.1080/0142159X.2017.1294749

Jacobson, E. (1938). *Progressive Relaxation*. University of Chicago Press.

Jahoda, A., Stenfert Kroese, B., Pert, C., Jahoda, A., Stenfert Kroese, B., & Pert, C. (2017). Mindfulness and Third Wave Therapies. In *Cognitive Behaviour Therapy for People with Intellectual Disabilities* (pp. 181–212). Palgrave Macmillan UK. DOI: 10.1057/978-1-137-47854-2_9

Jain, S., Shapiro, S. L., Swanick, S., Roesch, S. C., Mills, P. J., Bell, I., & Schwartz, G. E. R. (2007). A randomized controlled trial of mindfulness meditation versus relaxation training: Effects on distress, positive states of mind, rumination, and distraction. *Annals of Behavioral Medicine*, *33*(1), 11–21. DOI: 10.1207/s15324796abm3301_2

Jensen, L., & Konradsen, F. (2018). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies*, *23*(4), 1515–1529. DOI: 10.1007/s10639-017-9676-0

Jia, Y. F., & Loo, Y. T. (2018). Prevalence and determinants of perceived stress among undergraduate students in a Malaysian university. *Journal of Health and*

*Translational Medicine*, *21*(1), 1–5. http://ijie.um.edu.my/index.php/jummec/article/view/11016

Keng, S. L., Phang, C. K., & Oei, T. P. (2015). Effects of a brief mindfulness-based intervention program on psychological symptoms and well-being among medical students in Malaysia: A controlled study. *International Journal of Cognitive Therapy*, *8*(4), 335–350. DOI: 10.1521/ijct.2015.8.4.335

Khoury, B., Lecomte, T., Fortin, G., Masse, M., Therien, P., Bouchard, V., Chapleau, M. A., Paquin, K., & Hofmann, S. G. (2013). Mindfulness-based therapy: A comprehensive meta-analysis. *Clinical Psychology Review*, *33*(6), 763–771. DOI: 10.1016/j.cpr.2013.05.005

Kothgassner, O. D., Goreis, A., Kafka, J. X., Van Eickels, R. L., Plener, P. L., & Felnhofer, A. (2019). Virtual reality exposure therapy for posttraumatic stress disorder (PTSD): a meta-analysis. *European Journal of Psychotraumatology*, *10*(1), 1654782. DOI: 10.1080/20008198.2019.1654782

Koydemir, S., & Schütz, A. (2012). Emotional intelligence predicts components of subjective well-being beyond personality: A two-country study using self- and informant reports. *Journal of Positive Psychology*, *7*(2), 107–118. DOI: 10.1080/17439760.2011.647050

Kuhlmann, S. M., Huss, M., Bürger, A., & Hammerle, F. (2016). Coping with stress in medical students: results of a randomized controlled trial using a mindfulness-based stress prevention training (MediMind) in Germany. *BMC Medical Education*, *16*(1), 1–11. DOI: 10.1186/s12909-016-0833-8

Kuyken, W., Byford, S., Taylor, R. S., Watkins, E., Holden, E., White, K., Barrett, B., Byng, R., Evans, A., Mullan, E., & Teasdale, J. D. (2008). Mindfulness-Based Cognitive Therapy to Prevent Relapse in Recurrent Depression. *Journal of Consulting and Clinical Psychology*, *76*(6), 966–978. DOI: 10.1037/a0013786

Lever Taylor, B., Strauss, C., Cavanagh, K., & Jones, F. (2014). The effectiveness of self-help mindfulness-based cognitive therapy ina student sample: A randomised controlled trial. *Behaviour Research and Therapy*, *63*, 63–69. DOI: 10.1016/j.brat.2014.09.007

Lockhart, G., MacKinnon, D. P., & Ohlrich, V. (2011). Mediation analysis in psychosomatic medicine research. *Psychosomatic Medicine*, *73*(1), 29–43. DOI: 10.1097/PSY.0b013e318200a54b

Lynch, S., Gander, M. L., Nahar, A., Kohls, N., & Walach, H. (2018). Mindfulness-Based Coping With University Life: A Randomized Wait-List Controlled Study. *SAGE Open*, *8*(1), 215824401875837. DOI: 10.1177/2158244018758379

Malloy, K. M., & Milling, L. S. (2010). The effectiveness of virtual reality distraction for pain reduction: A systematic review. *Clinical Psychology Review*, *30*(8), 1011–1018. DOI: 10.1016/j.cpr.2010.07.001

McConville, J., McAleer, R., & Hahne, A. (2017). Mindfulness Training for Health Profession Students—The Effect of Mindfulness Training on Psychological Well-Being, Learning and Clinical Performance of Health Professional Students: A Systematic Review of Randomized and Non-randomized Controlled Trials. *Explore: The Journal of Science and Healing*, *13*(1), 26–45. DOI:

10.1016/j.explore.2016.10.002

McIndoo, C. C., File, A. A., Preddy, T., Clark, C. G., & Hopko, D. R. (2016). Mindfulness-based therapy and behavioral activation: A randomized controlled trial with depressed college students. *Behaviour Research and Therapy*, *77*, 118–128. DOI: 10.1016/j.brat.2015.12.012

Morris, S. B. (2008). Estimating effect sizes from pretest-posttest-control group designs. *Organizational Research Methods*, *11*(2), 364–386. DOI: 10.1177/1094428106291059

Mortier, P., Cuijpers, P., Kiekens, G., Auerbach, R. P., Demyttenaere, K., Green, J. G., Kessler, R. C., Nock, M. K., & Bruffaerts, R. (2018). The prevalence of suicidal thoughts and behaviours among college students: A meta-analysis. *Psychological Medicine*, *48*(4), 554–565. DOI: 10.1017/S0033291717002215

Nam, S., & Toneatto, T. (2016). The Influence of Attrition in Evaluating the Efficacy and Effectiveness of Mindfulness-Based Interventions. *International Journal of Mental Health and Addiction*, *14*(6), 969–981. DOI: 10.1007/s11469-016-9667-1

Navarro-Haro, M. V., López-del-Hoyo, Y., Campos, D., Linehan, M. M., Hoffman, H. G., García-Palacios, A., Modrego-Alarcón, M., Borao, L., & García-Campayo, J. (2017). Meditation experts try Virtual Reality Mindfulness: A pilot study evaluation of the feasibility and acceptability of Virtual Reality to facilitate mindfulness practice in people attending a Mindfulness conference. *PLoS ONE*, *12*(11), e0187777. DOI: 10.1371/journal.pone.0187777

Navarro-Haro, M. V., Modrego-Alarcón, M., Hoffman, H. G., López-Montoyo, A., Navarro-Gil, M., Montero-Marin, J., García-Palacios, A., Borao, L., & García-Campayo, J. (2019). Evaluation of a mindfulness-based intervention with and without virtual reality dialectical behavior therapy® mindfulness skills training for the treatment of generalized anxiety disorder in primary care: A pilot study. *Frontiers in Psychology*, *10*(JAN). DOI: 10.3389/fpsyg.2019.00055

Neff, K. (2003). The development and validation of a scale to measure self-compassion. *Self and Identity*, *2*(793220055), 223–250. DOI: 10.1080/15298860390209035

Neff, K. D., Tóth-Király, I., Yarnell, L. M., Arimitsu, K., Castilho, P., Ghorbani, N., Guo, H. X., Hirsch, J. K., Hupfeld, J., Hutz, C. S., Kotsou, I., Lee, W. K., Montero-Marin, J., Sirois, F. M., De Souza, L. K., Svendsen, J. L., Wilkinson, R. B., & Mantzios, M. (2019). Examining the factor structure of the Self-Compassion Scale in 20 diverse samples: Support for use of a total score and six subscale scores. *Psychological Assessment*, *31*(1), 27–45. DOI: 10.1037/pas0000629

Parsons, C. E., Crane, C., Parsons, L. J., Fjorback, L. O., & Kuyken, W. (2017). Home practice in Mindfulness-Based Cognitive Therapy and Mindfulness-Based Stress Reduction: A systematic review and meta-analysis of participants' mindfulness practice and its association with outcomes. *Behaviour Research and Therapy*, *95*, 29–41. DOI: 10.1016/j.brat.2017.05.004

Peckham, E., Brabyn, S., Cook, L., Devlin, T., Dumville, J., & Torgerson, D. J. (2015). The use of unequal randomisation in clinical trials - An update. *Contemporary Clinical Trials*, *45*(Pt A), 113–122. DOI: 10.1016/j.cct.2015.05.017

Pedrelli, P., Nyer, M., Yeung, A., Zulauf, C., & Wilens, T. (2015). College students:

Mental health problems and treatment considerations. *Academic Psychiatry*, *39*(5), 503–511. DOI: 10.1007/s40596-014-0205-9

Pérez-Aranda, A., Feliu-Soler, A., Montero-Marín, J., García-Campayo, J., Andrés-Rodríguez, L., Borràs, X., Rozadilla-Sacanell, A., Peñarrubia-Maria, M. T., Angarita-Osorio, N., McCracken, L. M., & Luciano, J. V. (2019). A randomized controlled efficacy trial of mindfulness-based stress reduction compared with an active control group and usual care for fibromyalgia: the EUDAIMON study. *Pain*, *160*(11), 2508–2523. DOI: 10.1097/j.pain.0000000000001655

Phang, C. K., Mukhtar, F., Ibrahim, N., Keng, S. L., & Mohd. Sidik, S. (2015). Effects of a brief mindfulness-based intervention program for stress management among medical students: the Mindful-Gym randomized controlled study. *Advances in Health Sciences Education*, *20*(5), 1115–1134. DOI: 10.1007/s10459-015-9591-3

Regehr, C., Glancy, D., & Pitts, A. (2013). Interventions to reduce stress in university students: A review and meta-analysis. *Journal of Affective Disorders*, *148*(1), 1–11. DOI: 10.1016/j.jad.2012.11.026

Reiss, N., Warnecke, I., Tibubos, A. N., Tolgou, T., Luka-Krausgrill, U., & Rohrmann, S. (2019). Effects of cognitive-behavioral therapy with relaxation vs. imagery rescripting on psychophysiological stress responses of students with test anxiety in a randomized controlled trial. *Psychotherapy Research*, *29*(8), 974–985. DOI: 10.1080/10503307.2018.1475767

Remor, E. (2006). Psychometric properties of a European Spanish version of the Perceived Stress Scale (PSS). *Spanish Journal of Psychology*, *9*(1), 86–93. DOI: 10.1017/S1138741600006004

Richards, D. A., & Borglin, G. (2011). Implementation of psychological therapies for anxiety and depression in routine practice: Two year prospective cohort study. *Journal of Affective Disorders*, *133*(1–2), 51–60. DOI: 10.1016/j.jad.2011.03.024

Royston, P., & White, I. (2015). Multiple Imputation by Chained Equations (MICE): Implementation in Stata. *Journal of Statistical Software*, *45*(4), 1–20. DOI: 10.18637/jss.v045.i04

Sandín, B., Chorot, P., Lostao, L., Joiner, T. E., Santed, M. A., & Valiente, R. M. (1999). Escalas PANAS de afecto positivo y negativo - Validación factorial y convergencia transcultural. *Psicothema*, *11*(1), 37–51. http://www.psicothema.com/psicothema.asp?id=229

Schaufeli, W. B., Martínez, I. M., Pinto, A. M., Salanova, M., & Barker, A. B. (2002). Burnout and engagement in university students a cross-national study. *Journal of Cross-Cultural Psychology*, *33*(5), 464–481. DOI: 10.1177/0022022102033005003

Shaw, M. P., Peart, D. J., & Fairhead, O. J. W. (2017). Perceived stress in university students studying in a further education college. *Research in Post-Compulsory Education*, *22*(3), 442–452. DOI: 10.1080/13596748.2017.1362534

Song, Y., & Lindquist, R. (2015). Effects of mindfulness-based stress reduction on depression, anxiety, stress and mindfulness in Korean nursing students. *Nurse Education Today*, *35*(1), 86–90. DOI: 10.1016/j.nedt.2014.06.010

Spielberger, C. D., & Gorsuch, R. L. (1983). *Manual for the state-trait anxiety*

*inventory (form Y):(" self-evaluation questionnaire")*. Palo Alto, CA: Consulting Psychologists Press. https://ubir.buffalo.edu/xmlui/handle/10477/2895

Stallman, H. M. (2010). Psychological distress in university students: A comparison with general population data. *Australian Psychologist*, *45*(4), 249–257. DOI: 10.1080/00050067.2010.482109

Torres, A. (2018). Realidad Virtual aplicada al mindfulness: Entornos e investigaciones de Psious para adultos y menores. *5th International Meeting on Mindfulness*.

Torres, A., Estapé, T., Gutiérrez, J., Abad, A., & García, M. (2017). Use of Virtual Reality (VR) with Mindfulness to reduce anticipatory chemotherapy induced anxiety. *IPOS World Congress of Psycho-Oncology*.

Van D'Ijk, I., Lucassen, P. L. B. J., Akkermans, R. P., Van Engelen, B. G. M., Van Weel, C., & Speckens, A. E. M. (2017). Effects of mindfulness-based stress reduction on the mental health of clinical clerkship students: A cluster-randomized controlled trial. *Academic Medicine*, *92*(7), 1012–1021. DOI: 10.1097/ACM.0000000000001546

Vijayananthan, A., & Nawawi, O. (2008). The importance of Good Clinical Practice guidelines and its role in clinical trials. *Biomedical Imaging and Intervention Journal*, *4*(1), e5. DOI: 10.2349/biij.4.1.e5

Walsh, E. C. (2011). Effects of a short-term mindfulness intervention on depression and immune fuction [University of Kentucky, Lexington, United States of America]. In *Theses and Dissertations-Psychology*. https://uknowledge.uky.edu/psychology_etds/2

Warnecke, E., Quinn, S., Ogden, K., Towle, N., & Nelson, M. R. (2011). A randomised controlled trial of the effects of mindfulness practice on medical student stress levels. *Medical Education*, *45*(4), 381–388. DOI: 10.1111/j.1365-2923.2010.03877.x

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. DOI: 10.1037/0022-3514.54.6.1063

Wiederhold, B. K., Riva, G., & Gutiérrez-Maldonado, J. (2016). Virtual reality in the assessment and treatment of weight-related disorders. *Cyberpsychology, Behavior, and Social Networking*, *19*(2), 67–73. DOI: 10.1089/cyber.2016.0012

Yusoff, M. S. B., Abdul Rahim, A. F., & Yaacob, M. J. (2010). Prevalence and sources of stress among Universiti Sains Malaysia medical students. *Malaysian Journal of Medical Sciences*, *17*(1), 30–37. www.mjms.usm.my

**Table 1**. Summary of the structure and contents of the interventions.

| Session | Mindfulness-based programme | Virtual reality scenarios | Relaxation therapy |
|---|---|---|---|
| 1 | **An introduction to mindfulness**<br>Group introductions and presentation of the objectives. Exercise: Breathing exercise.<br>Informal mindfulness practices: simple exercises (listening to sounds, contact with the soles of the feet, contact with clothing); raisin meditation exercise; savouring; de-mechanisation of a routine activity. | **Training the mind and savouring exercise**<br>Set in a conscious walking environment. In the first part, the participant is instructed to focus attention on the visual channel, observing how the leaves of a tree fall.<br>In the second exercise, the participant is instructed to be aware of bodily sensations while observing a lemon. (7'32''). | **Basic principles of progressive muscle relaxation**<br>Group introductions and presentation of the objectives. Systematic tension and release of 16 muscle groups.<br>Progressive muscle relaxation exercise with 16 muscle groups. Imagination training.<br>Identification of sensations and difficulties with relaxation. |
| 2 | **What are thoughts and how can I relate to them?**<br>Thoughts and managing thoughts. Figure of the observer of thoughts; the world of interpretations and judgements. The beginner's mind, balancing the pros and cons. Self-fulfilling prophecies. Body sensations as anchoring point.<br>Exercise: Body scan.<br>Informal mindfulness practices: hello, thanks & goodbye; visual metaphors of the mind; three compassionate minutes. | **Body-scan exercise**<br>The simulation of a human figure is used in this exercise. Throughout it, different body areas of this figure are highlighted (by means of blue bubbles) while the participant is instructed to become aware of the bodily sensations that correspond to each illuminated area.<br>The exercise consists of a guided body-scan with visual support (7'32''). | **Inclusion of visualization techniques**<br>Sharing experiences of daily life. Visualization techniques.<br>Progressive muscle relaxation with 16 muscle groups. Orange exercise (visualization).<br>Identification of sensations and difficulties with relaxation. |
| 3 | **The body, much more than a 'vehicle for transporting the mind'/Time**<br>How to structure mindfulness practice, difficulties and adjustments: body movement and body sensations as an anchoring point, time management, and procrastination.<br>Exercises: Mindful walking, mindful body movements.<br>Informal mindfulness practice: mindful walking, mindful sighing, recording the time. | **Conscious observation exercise**<br>This exercise is set in a spring landscape; the participant is asked to focus attention on several elements of the natural landscape while walking. When the participant arrives at a bonfire, they are explained the concept of the 'figure of the observer of thoughts': observing one's own thoughts without being trapped by them.<br>At the end of this exercise, the camera will move away to ask the participant to observe the landscape from the new perspective (8'22''). | **Progressive relaxation of 7 muscle groups**<br>Sharing experiences of daily life. Systematic tension and release of 7 muscle groups.<br>Progressive relaxation with 7 muscle groups. The beach exercise (visualization).<br>Identification of sensations and difficulties with relaxation. |

| | | | |
|---|---|---|---|
| 4 | **What are emotions and how can I relate to them? The reality of suffering and acceptance**<br>Emotions and managing emotions. The observer. Embracing emotion. Pain or primary suffering and secondary suffering. Acceptance. Preparing ourselves for self-compassion: kind attention.<br>Exercises: compassionate breathing, compassionate body scan.<br>Informal mindfulness practice: inhaling/exhaling in difficult situations. | **Compassionate coping in a difficult situation**<br>The first part of this exercise is based on identifying and recreating a life situation in which the participant has experienced a negative emotion. In the second part of this exercise, the participant is instructed to accept and let go of the emotion which has emerged from this difficult situation (10'). | **Progressive relaxation training with visualization**<br>Sharing experience of daily tasks.<br>Progressive muscle relaxation exercise with 7 muscle groups; landscape exercise (visualization).<br>Identification of sensations and difficulties with relaxation. |
| 5 | **Challenges at university/Self-compassion: a new way of being with yourself**<br>Stress, anxiety and other challenges at university. Knowing and managing your own critical voice. Self-compassion and its usefulness in daily life.<br>Exercises: identifying and substituting the destructive self-critical voice for one that is more constructive; compassionate coping in difficult situations; receiving good wishes.<br>Informal mindfulness practice: recording stressful events. | **Breathing in exams**<br>This exercise helps to find calm and serenity in a difficult situation such as an examination. The participant is immersed in an exam situation taking place at the university.<br>Before doing the exam, the participant is invited to hear a 5-minute breathing exercise audio recording. When it finishes, the participant can do the exam using a virtual tablet (10'). | **Progressive relaxation of 4 muscle groups**<br>Sharing experiences of daily tasks. Systematic tension and release of 7 muscle groups.<br>Progressive muscle relaxation exercise with 4 muscle groups; the globe and white light exercise (visualization).<br>Identification of sensations and difficulties with relaxation. |
| 6 | **Mindfulness and self-compassion, new allies in our day-to-day**<br>Recap of the main concepts; how to incorporate what has been learnt into daily life and into the university study context. Group farewell.<br>Exercises: revision of the main formal and informal mindfulness and compassion exercises; Calming contact exercise; a compassionate letter to yourself.<br>Informal mindfulness practice: music, art, literature and other tools for strengthening concepts of mindfulness and compassion; thanking exercise. | **Gratitude exercise**<br>This exercise is set in a desert scenario. It is based on 1) identifying and being aware of three positive aspects of the participant's life and 2) showing gratitude for them.<br>These three aspects are represented by three geometric figures located in the landscape. This exercise develops thankfulness and the concept of 'loving kindness' (2'40''). | **Relaxation through recall**<br>Sharing experiences of daily tasks.<br>Relaxation through recall; mental relaxation and 'the perfect day' exercise (visualization).<br>Identification of sensations and difficulties with relaxation. |

***Note***: This mindfulness programme has been designed by some of the authors of the present article. Each VR exercise was carefully selected from a large list of mindfulness practices developed by professionals with extensive experience in the field of mindfulness to make sure that each VR session corresponded to the contents provided in each group session and supports the learning of the session. The relaxation therapy is an adapted version proposed by Bernstein and Borkovec (1973) of the Progressive Muscle Relaxation.

**Table 2.** Baseline characteristics of participants by treatment group.

| | MBP (n = 93) | MBP+VR (n = 93) | Relaxation (n = 94) | TOTAL (N = 280) |
|---|---|---|---|---|
| **Sex, n (%)** [n.s.] | | | | |
| Females | 74 (79.6%) | 72 (77.4%) | 75 (79.8%) | 221 (78.9%) |
| Males | 19 (20.4%) | 21 (22.6%) | 19 (20.2%) | 59 (21.1%) |
| **Age, mean (SD)** [n.s.] | 21.95 (5.04) | 22.86 (6.41) | 21.96 (5.71) | 22.25 (5.74) |
| **Nationality, n (%)** [n.s.] | | | | |
| Spanish | 92 (98.9%) | 87 (93.6%) | 90 (95.8%) | 269 (96.1%) |
| Others | 1 (1.1%) | 6 (6.4%) | 4 (4.2%) | 11 (3.9%) |
| **Relationships, n (%)** [n.s.] | | | | |
| no relationship | 52 (55.9%) | 46 (49.5%) | 58 (61.7%) | 156 (55.7%) |
| stable relationship | 41 (44.1%) | 47 (50.5%) | 36 (38.3%) | 124 (44.3%) |
| **Study area, n (%)** [n.s.] | | | | |
| Health | 67 (72.0%) | 68 (73.1%) | 70 (74.5%) | 205 (73.2%) |
| Social | 26 (28.0%) | 25 (26.9%) | 24 (25.5%) | 75 (26.8%) |
| **Course, n (%)** [n.s.] | | | | |
| 1–3 | 73 (78.5%) | 73 (78.5%) | 84 (89.4%) | 230 (82.1%) |
| 4–6 | 20 (21.5%) | 20 (21.5%) | 10 (10.6%) | 50 (17.9%) |
| **Education level, n (%)** [n.s.] | | | | |
| Undergraduate | 92 (98.9%) | 88 (94.6%) | 90 (95.7%) | 270 (96.4%) |
| Taught master | 1 (1.1%) | 5 (5.4%) | 4 (4.3%) | 10 (3.6%) |
| **Employment status, n (%)*** | | | | |
| Employed | 13 (14.0%) | 17 (18.3%) | 28 (29.8%) | 58 (70.7%) |
| Unemployed | 80 (86.0%) | 76 (81.7%) | 66 (70.2%) | 222 (29.3%) |

***Note:*** MBP = group mindfulness-based programme training only. MPB+VR = group mindfulness-based programme training plus individual mindfulness virtual reality training. Relaxation = group relaxation therapy. * means statistically significant differences ($p < .050$) between the three treatment conditions. [n.s.] means no statistically significant differences ($p > .05$) between the three treatment conditions.

**Table 3.** Adjusted descriptive statistics and between-group analyses for primary and secondary outcomes (ITT approach).

| | MBP | MBP+VR | Relaxation | Relaxation vs MBP | | | Relaxation vs MBP+VR | | | MBP+VR vs MBP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Mean* (*SD*) | *Mean* (*SD*) | *Mean* (*SD*) | *d* | *t* (*p*) | *B* (95% CI) | *d* | *t* (*p*) | *B* (95% CI) | *d* | *t* (*p*) | *B* (95% CI) |
| **PSS (0–40)** | | | | | | | | | | | | |
| **Baseline** | 19.73 (4.02) | 19.81 (4.41) | 19.35 (3.63) | | | | | | | | | |
| **Post-treatment *** | 15.33 (4.50) | 15.75 (4.51) | 17.73 (4.52) | -0.72 | -2.72 (**.006**) | -2.77 (-4.77, -0.78) | -0.59 | -2.45 (**.014**) | -2.44 (-4.39, -0.49) | -0.08 | -0.34 (.734) | -0.33 (-2.24, 1.58) |
| **Follow-up** | 16.11 (5.51) | 15.52 (5.81) | 18.65 (5.18) | -0.75 | -2.45 (**.014**) | -2.98 (-5.37, -0.60) | -0.87 | -3.02 (**.003**) | -3.64 (-6.00, -1.28) | 0.16 | 0.53 (.594) | 0.66 (-1.77, 3.09) |
| **STAI trait (0–60)** | | | | | | | | | | | | |
| **Baseline** | 26.27 (4.73) | 26.15 (5.23) | 25.16 (4.30) | | | | | | | | | |
| **Post-treatment** | 20.29 (5.41) | 21.37 (5.41) | 23.54 (5.42) | -0.95 | -2.69 (**.007**) | -3.36 (-5.81, -0.91) | -0.64 | -1.76 (.079) | -2.15 (-4.56, .25) | -0.24 | -0.92 (.359) | -1.18 (-3.70, 1.34) |
| **Follow-up** | 19.14 (7.87) | 19.07 (7.80) | 24.92 (7.78) | -1.51 | -3.36 (**.001**) | -5.34 (-8.45, -2.23) | -1.41 | -2.70 (**.007**) | -4.24 (-7.31, -1.17) | -0.01 | -0.66 (.506) | -1.09 (-3.70, 1.34) |
| **STAI state (0–60)** | | | | | | | | | | | | |
| **Baseline** | 22.09 (5.83) | 21.86 (6.43) | 22.07 (5.31) | | | | | | | | | |
| **Post-treatment** | 15.34 (6.62) | 16.73 (6.62) | 17.53 (6.62) | -0.39 | -1.42 (.156) | -2.20 (-5.25, .84) | -0.10 | -0.39 (.696) | -0.59 (-3.56, 2.37) | -0.26 | -1.03 (.301) | -1.62 (-4.68, 1.45) |
| **Follow-up** | 14.27 (7.30) | 15.29 (7.58) | 21.98 (7.07) | -1.37 | -4.45 (**<.001**) | -7.74 (-11.14, -4.33) | -1.08 | -3.77 (**<.001**) | -6.42 (-9.76, -3.09) | -0.20 | -0.75 (.456) | -1.25 (-4.52, 2.03) |
| **PANAS balance (-40–+40)** | | | | | | | | | | | | |
| **Baseline** | 9.23 (5.75) | 9.20 (6.23) | 9.27 (5.12) | | | | | | | | | |
| **Post-treatment** | 14.99 (6.45) | 15.73 (6.45) | 12.67 (6.46) | 0.43 | 1.60 (.110) | 2.36 (-0.54, 5.25) | 0.54 | 2.15 (**.032**) | 3.13 (0.27, 5.99) | -0.13 | -0.53 (.595) | -0.77 (-3.61, 2.07) |
| **Follow-up** | 16.95 (7.07) | 17.28 (7.08) | 11.35 (7.08) | 1.02 | 3.37 (**<.001**) | 5.64 (2.36, 8.92) | 1.03 | 3.58 (**<.001**) | 5.98 (2.71, 9.25) | -0.06 | -0.21 (.836) | -0.36 (-3.80, 3.07) |
| **UWES (0–102)** | | | | | | | | | | | | |
| **Baseline** | 58.29 (5.72) | 58.47 (6.18) | 58.46 (5.19) | | | | | | | | | |
| **Post-treatment** | 61.39 (6.43) | 62.81 (6.44) | 59.30 (6.44) | 0.41 | 1.54 (.124) | 2.26 (-0.62, 5.15) | 0.60 | 2.42 (**.015**) | 3.50 (0.67, 6.34) | -0.21 | -0.86 (.391) | -1.27 (-4.17, 1.63) |
| **Follow-up** | 66.37 (7.44) | 63.27 (7.46) | 60.27 (7.43) | 1.14 | 3.56 (**<.001**) | 6.35 (2.86, 9.85) | 0.51 | 1.65 (.099) | 2.91 (-0.55, 6.37) | 0.55 | 1.94 (.053) | 3.43 (-0.04, 6.90) |
| **MBI (0–90)** | | | | | | | | | | | | |
| **Baseline** | 27.47 (4.93) | 27.40 (5.42) | 27.04 (4.45) | | | | | | | | | |
| **Post-treatment** | 23.89 (5.57) | 24.31 (5.58) | 25.77 (5.60) | -0.49 | -1.80 (.072) | -2.31 (-4.82, 0.20) | -0.36 | -1.45 (.148) | -1.82 (-4.28, .65) | -0.09 | -0.37 (.713) | -0.49 (-3.10, 2.12) |
| **Follow-up** | 21.35 (6.77) | 24.99 (6.79) | 28.52 (6.80) | -1.60 | -4.68 (**<.001**) | -7.59 (-10.77, -4.41) | -0.77 | -2.42 (**.016**) | -3.88 (-7.03, -0.73) | -0.71 | -2.26 (**.024**) | -3.72 (-6.95, -0.50) |
| **ERQ reappraisal (6–42)** | | | | | | | | | | | | |
| **Baseline** | 26.87 (3.67) | 26.89 (4.09) | 27.25 (3.35) | | | | | | | | | |
| **Post-treatment** | 29.59 (4.20) | 28.07 (4.21) | 28.11 (4.21) | 0.52 | 1.91 (.056) | 1.86 (-0.05, 3.77) | 0.08 | 0.34 (.731) | 0.33 (-1.54, 2.19) | 0.39 | 1.61 (.107) | 1.54 (-0.34, 3.42) |
| **Follow-up** | 29.71 (4.35) | 29.03 (4.35) | 27.77 (4.35) | 0.65 | 2.19 (**.029**) | 2.32 (0.24, 4.40) | 0.57 | 1.50 (.134) | 1.57 (-0.49, 3.62) | 0.20 | 0.71 (.480) | 0.74 (-1.32, 2.80) |
| **ERQ suppression (4–28)** | | | | | | | | | | | | |
| **Baseline** | 13.85 (2.32) | 13.84 (2.51) | 14.01 (2.08) | | | | | | | | | |
| **Post-treatment** | 12.00 (2.60) | 12.41 (2.61) | 13.75 (2.61) | -0.71 | -2.63 (**.008**) | -1.58 (-2.75, -0.40) | -0.50 | -1.99 (**.047**) | -1.17 (-2.32, -0.02) | -0.17 | -0.68 (.496) | -0.41 (-1.57, 0.76) |
| **Follow-up** | 10.72 (2.87) | 10.98 (2.88) | 12.42 (2.88) | -0.69 | -2.15 (**.031**) | -1.47 (-2.81, -0.13) | -0.54 | -1.77 (.076) | -1.20 (-2.52, .13) | -0.11 | -0.42 (.678) | -0.27 (-1.57, 1.02) |
| **FFMQ (39–195)** | | | | | | | | | | | | |
| **Baseline** | 120.14 (9.48) | 120.05 (10.73) | 121.00 (8.37) | | | | | | | | | |
| **Post-treatment** | 135.48 (10.90) | 133.39 (10.92) | 127.17 (10.98) | 1.01 | 3.50 (**<.001**) | 9.19 (4.04, 14.33) | 0.72 | 2.84 (**.005**) | 7.18 (2.22, 12.15) | 0.20 | 0.75 (.456) | 1.98 (-3.23, 7.19) |
| **Follow-up** | 137.25 (11.18) | 139.25 (11.21) | 127.96 (11.28) | 1.12 | 3.69 (**<.001**) | 10.31 (4.84, 15.78) | 1.24 | 4.56 (**<.001**) | 12.46 (7.11, 17.81) | -0.21 | -0.72 (.473) | -2.08 (-7.77, 3.60) |
| **SCS (26–130)** | | | | | | | | | | | | |
| **Baseline** | 73.77 (8.32) | 73.69 (8.96) | 74.22 (7.51) | | | | | | | | | |
| **Post-treatment** | 86.96 (9.42) | 85.98 (9.42) | 78.57 (9.47) | 1.10 | 4.03 (**<.001**) | 8.84 (4.54, 13.14) | 0.94 | 3.69 (**<.001**) | 7.93 (3.72, 12.13) | 0.10 | 0.38 (.708) | 0.86 (-3.62, 5.33) |
| **Follow-up** | 86.64 (9.27) | 89.67 (9.28) | 77.78 (9.27) | 1.16 | 4.06 (**<.001**) | 9.28 (4.80, 13.75) | 1.47 | 5.51 (**<.001**) | 12.42 (8.00, 16.85) | -0.36 | -1.32 (.185) | -3.11 (-7.70, 1.49) |

***Note:*** MBP+VR = group mindfulness-based programme training plus individual mindfulness virtual reality training. MPB = group mindfulness-based programme training only. Relaxation = group relaxation therapy training. * Main outcome at the primary endpoint.

**Table 4**. Dose-response analyses for the primary outcome (PSS).

| Group | Dosage | B (95% CI) | *t* | p |
|---|---|---|---|---|
| | *per session* | | | |
| 'MBP' | | -0.81 (-1.39, -0.22) | -2.70 | **.007** |
| 'MBP+VR' | | -0.80 (-1.59, -0.02) | -2.00 | **.045** |
| 'Relaxation' | | -0.37 (-0.90, 0.17) | -1.35 | .178 |
| | *≥50% sessions* | | | |
| 'MBP' | | -3.99 (-6.71, -1.26) | -2.87 | **.004** |
| 'MBP+VR' | | -6.40 (-12.35, -0.45) | -2.11 | **.035** |
| 'Relaxation' | | -1.42 (-3.48, 0.65) | -1.34 | .180 |

***Note:*** 'Relaxation': relaxation therapy. 'MBP': group mindfulness-based programme alone. 'MBP+VR': group mindfulness-based programme accompanied by individual virtual reality support.

**Figure 1.** Timeline.

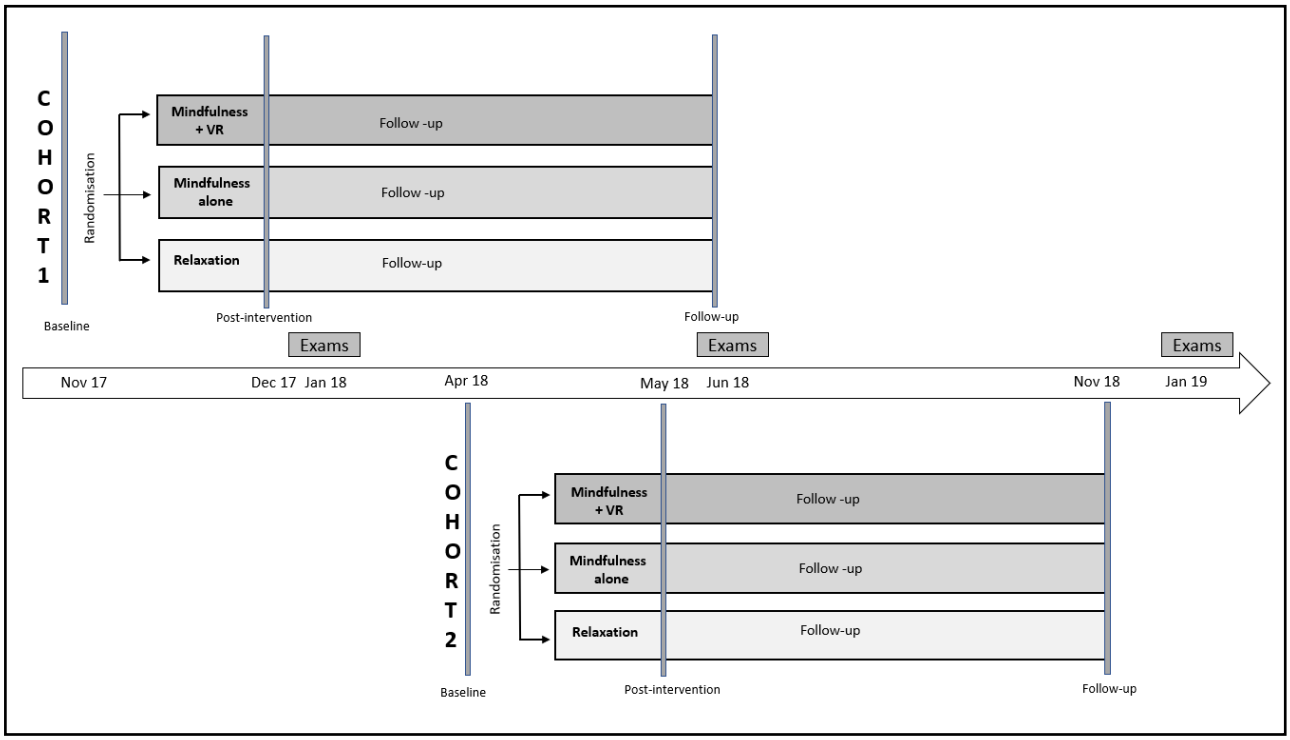


**Figure 2.** Flow chart of participants in the randomized controlled trial.

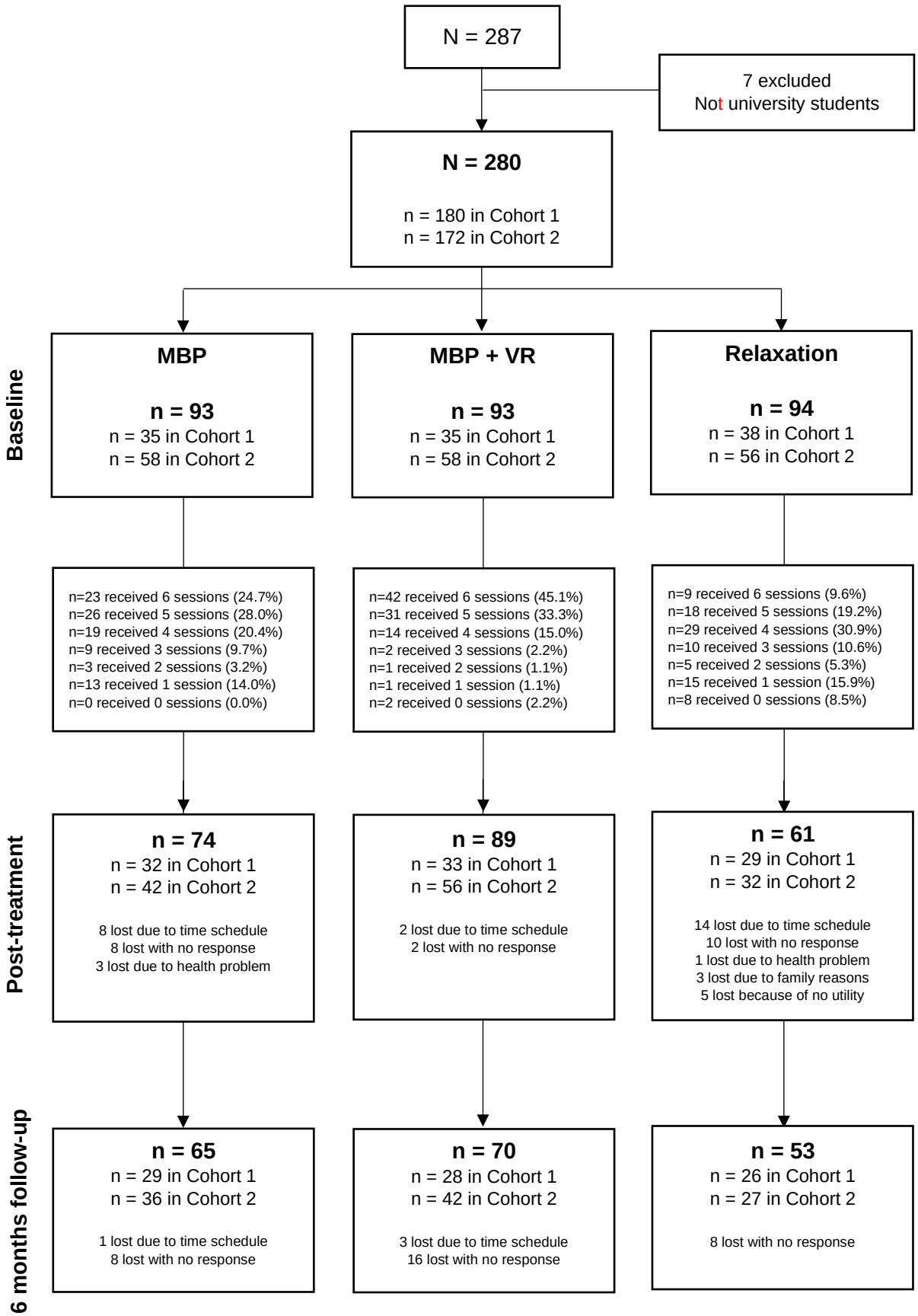
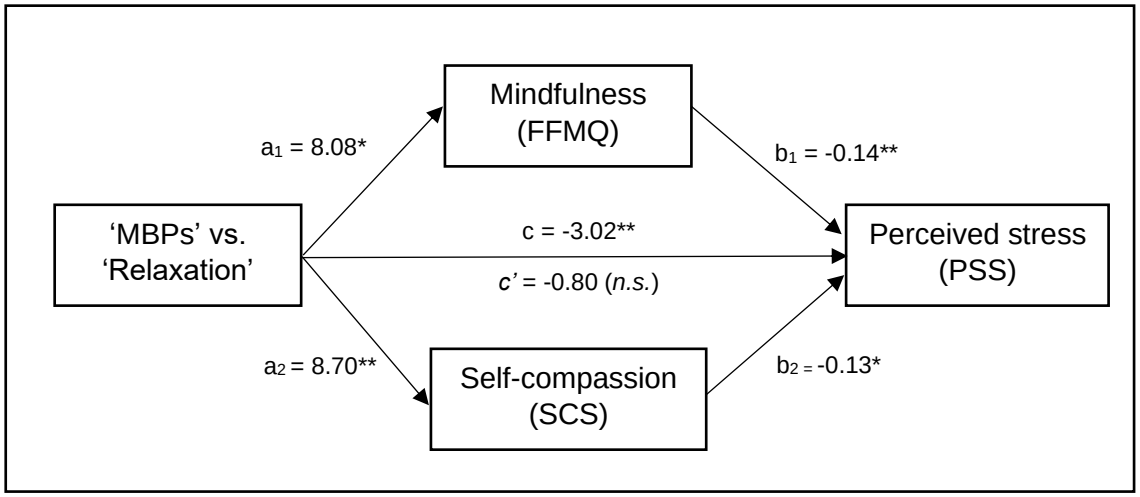


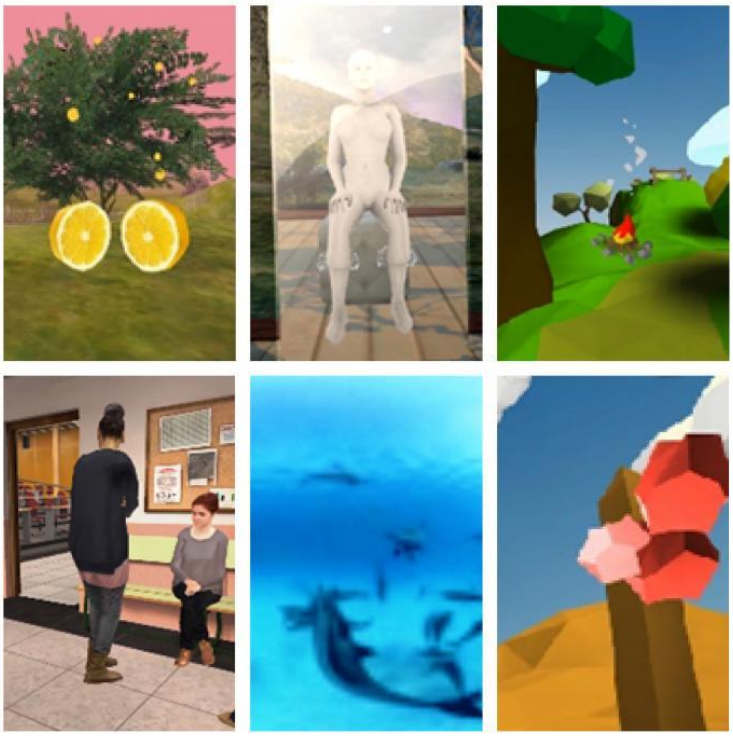
**Figure 3.** Parallel multiple mediating effects of mindfulness (FFMQ) and self-compassion (SCS) in their relationship between the use of mindfulness-based programmes ('MBPs') vs. 'relaxation' therapy and perceived stress (PSS).




***Notes***: All presented effects are unstandardized. $a_1$ is the effect of the use of mindfulness-based programmes ('MBPs') vs 'Relaxation' therapy on FFMQ baseline-posttreatment change; $a_2$ is the effect of the use of 'MBPs' vs 'Relaxation' therapy on SCS baseline-posttreatment change; $b_1$ is the effect of FFMQ baseline-posttreatment change on PSS baseline to follow-up changes; $b_2$ is the effect of SCS baseline-posttreatment change on PSS baseline to follow-up changes; c' is the direct effect of the use of 'MBPs' vs 'Relaxation' therapy on PSS after controlling for the mediators; c is the total effect of the use of 'MBPs' vs 'Relaxation' therapy on PSS. n.s: not significant. * $p < .05$. ** $p < .001$.

**Supplementary material S1.**

Screenshots of virtual reality scenarios.



**Supplementary material S2.**

Regression model to assess baseline variables predicting missing primary outcome data (PSS at posttest and follow-up).

| | **Posttest** | | **Follow-up** | |
|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI |
| Arm, MBP+VR | **0.83** | **0.03 – 0.25** | **0.43** | **0.23 – 0.79** |
| Arm, MBP | **0.48** | **0.25 – 0.92** | 0.56 | 0.31 – 1.02 |
| Cohort, second | **2.17** | **1.12 – 4.20** | **2.12** | **1.23 – 3.64** |
| Sex, men | 0.47 | 0.20 – 1.11 | 0.96 | 0.52 – 1.78 |
| Age | 0.98 | 0.92 – 1.04 | 0.97 | 0.92 – 1.01 |
| Nationality, Spanish | 0.99 | 0.97 – 1.01 | 0.99 | 0.97 – 1.01 |
| Relationships, no | 1.42 | 0.78 – 2.59 | 1.57 | 0.94 – 2.61 |
| Study area, health sciences | 1.12 | 0.57 – 2.20 | 1.15 | 0.65 – 2.03 |
| Course, 4–6 | 0.86 | 0.39 – 1.88 | 0.76 | 0.39 – 1.49 |
| Education level, master | 0.16 | 0.01 – 2.83 | 0.08 | 0.01 – 1.43 |
| Employment status, employed | 1.73 | 0.89 – 3.39 | **1.92** | **1.06 – 3.47** |
| PSS, baseline | 1.03 | 0.99 – 1.07 | 1.02 | 0.99 – 1.06 |
| STAI trait, baseline | **1.03** | **1.00 – 1.06** | 1.02 | 0.99 – 1.05 |
| STAI state, baseline | 1.03 | 0.99 – 1.06 | 1.02 | 0.99 – 1.04 |
| PANAS balance, baseline | 0.99 | 0.96 – 1.01 | 0.98 | 0.96 – 1.01 |
| UWES, baseline | 1.00 | 0.98 – 1.02 | 0.99 | 0.98 – 1.01 |
| MBI, baseline | 1.01 | 0.98 – 1.03 | 1.01 | 0.99 – 1.03 |
| ERQ reappraisal, baseline | 1.03 | 0.98 – 1.08 | 1.02 | 0.98 – 1.06 |
| ERQ suppression, baseline | 0.99 | 0.94 – 1.05 | 0.99 | 0.95 – 1.04 |
| FFMQ total, baseline | 0.99 | 0.98 – 1.01 | 1.00 | 0.98 – 1.01 |
| SCS total, baseline | 0.99 | 0.97 – 1.01 | 1.00 | 0.98 – 1.01 |

MBP+VR = group mindfulness training plus individual mindfulness virtual reality training; MBP = group mindfulness training only. (Relaxation is the reference group).

**Supplementary material S3.**

Raw descriptive statistics for primary and secondary outcomes.

| Outcomes/time points | MBP | | MBP+VR | | Relaxation | |
|---|---|---|---|---|---|---|
| | *n* | *Mean* (*SD*) | *n* | *Mean* (*SD*) | *n* | *Mean* (*SD*) |
| **Primary outcome** | | | | | | |
| **PSS (0–40)** | | | | | | |
| **Baseline** | 93 | 20.11 (7.20) | 93 | 20.34 (7.52) | 94 | 18.76 (7.31) |
| **Post-treatment** | 74 | 15.66 (6.72) | 89 | 16.05 (5.82) | 61 | 16.41 (6.65) |
| **Follow-up** | 65 | 16.26 (6.86) | 70 | 15.71 (7.11) | 53 | 17.74 (7.36) |
| **Secondary outcomes** | | | | | | |
| **STAI trait (0–60)** | | | | | | |
| **Baseline** | 93 | 26.99 (9.85) | 91 | 26.01 (10.74) | 90 | 26.22 (10.74) |
| **Post-treatment** | 71 | 21.11 (9.64) | 87 | 20.89 (10.17) | 59 | 21.81 (9.18) |
| **Follow-up** | 61 | 19.25 (8.77) | 67 | 19.03 (10.85) | 54 | 23.54 (8.53) |
| **STAI state (0–60)** | | | | | | |
| **Baseline** | 89 | 22.54 (9.86) | 90 | 21.51 (12.01) | 87 | 22.43 (10.31) |
| **Post-treatment** | 71 | 15.90 (9.47) | 88 | 16.43 (10.04) | 59 | 16.44 (8.51) |
| **Follow-up** | 60 | 14.58 (9.31) | 69 | 14.65 (9.75) | 52 | 21.44 (10.94) |
| **PANAS balance (-40 – +40)** | | | | | | |
| **Baseline** | 93 | 9.03 (12.32) | 90 | 9.03 (12.16) | 92 | 9.21 (11.30) |
| **Post-treatment** | 74 | 14.64 (11.96) | 87 | 15.92 (11.28) | 58 | 13.76 (11.35) |
| **Follow-up** | 64 | 16.81 (11.44) | 68 | 17.47 (11.70) | 53 | 12.25 (10.25) |
| **UWES (0–102)** | | | | | | |
| **Baseline** | 91 | 56.56 (15.05) | 90 | 59.71 (15.06) | 92 | 58.71 (14.07) |
| **Post-treatment** | 74 | 60.20 (15.87) | 85 | 64.01 (15.92) | 61 | 59.85 (14.30) |
| **Follow-up** | 64 | 65.03 (17.21) | 68 | 65.91 (15.27) | 51 | 60.67 (13.73) |
| **MBI (0–90)** | | | | | | |
| **Baseline** | 92 | 28.65 (12.94) | 91 | 27.88 (13.05) | 91 | 25.86 (12.09) |
| **Post-treatment** | 72 | 24.85 (11.88) | 87 | 24.74 (11.80) | 59 | 23.48 (9.65) |
| **Follow-up** | 62 | 22.47 (12.70) | 68 | 25.75 (13.67) | 52 | 25.71 (12.42) |
| **ERQ reappraisal (6–42)** | | | | | | |
| **Baseline** | 92 | 26.47 (7.34) | 91 | 26.78 (6.43) | 90 | 27.88 (6.75) |
| **Post-treatment** | 71 | 29.18 (6.48) | 88 | 27.88 (6.13) | 60 | 28.20 (5.88) |
| **Follow-up** | 63 | 29.14 (6.92) | 71 | 29.23 (6.06) | 49 | 27.69 (5.86) |
| **ERQ suppression (4–28)** | | | | | | |
| **Baseline** | 92 | 13.49 (5.28) | 92 | 13.46 (5.96) | 91 | 14.67 (5.99) |
| **Post-treatment** | 74 | 11.84 (5.47) | 86 | 12.23 (5.72) | 60 | 14.60 (5.35) |
| **Follow-up** | 65 | 10.37 (4.80) | 71 | 10.78 (5.00) | 53 | 13.21 (5.24) |
| **Mechanistic outcomes** | | | | | | |
| **FFMQ (39–195)** | | | | | | |
| **Baseline** | 86 | 118.73 (19.40) | 89 | 118.14 (18.34) | 87 | 123.68 (17.87) |
| **Post-treatment** | 71 | 134.24 (19.44) | 89 | 131.74 (17.64) | 57 | 130.93 (19.54) |
| **Follow-up** | 62 | 136.89 (17.56) | 68 | 137.56 (18.53) | 49 | 132.27 (17.01) |
| **SCS (26–130)** | | | | | | |
| **Baseline** | 91 | 73.07 (15.09) | 93 | 72.56 (17.22) | 88 | 75.28 (16.79) |
| **Post-treatment** | 72 | 86.17 (15.56) | 84 | 85.18 (15.82) | 59 | 81.59 (14.58) |
| **Follow-up** | 63 | 86.51 (14.97) | 66 | 88.52 (15.78) | 46 | 80.04 (13.93) |

***Note:*** MBP+VR = group mindfulness-based programme training plus individual mindfulness virtual reality training. MPB = group mindfulness-based programme training only. Relaxation = group relaxation therapy training.

**Supplementary material S4.**

Adjusted within-group analyses for primary and secondary outcomes (ITT approach).

| | ***Pre–post*** | | ***Pre–follow-up*** | |
|---|---|---|---|---|
| **Outcomes/Groups** | *B* (95% CI) | *t (p)* | *B* (95% CI) | *t (p)* |
| **Primary outcome** | | | | |
| PSS (0–40) | | | | |
| Relaxation | -1.62 (-3.08, -0.17) | -2.19 **(.028)** | -0.68 (-2.42, 1.06) | -0.77 (.442) |
| MBP+VR | -4.06 (-5.37, -2.75) | -6.09 (**<.001**) | -4.32 (-5.92, -2.72) | -5.29 **(<.001)** |
| MBP | -4.40 (-5.77, -3.02) | -6.27 (**<.001**) | -3.66 (-5.30, -2.03) | -4.39 (**<.001**) |
| **Secondary outcomes** | | | | |
| STAI trait (0–60) | | | | |
| Relaxation | -2.62 (-4.42, -0.83) | -2.86 (**.004**) | -2.00 (-4.26, 0.26) | -1.73 (.083) |
| MBP+VR | -4.78 (-6.37, -3.18) | -5.86 (**<.001**) | -6.23 (-8.32, -4.15) | -5.87 (**<.001**) |
| MBP | -5.99 (-7.66, -4.32) | -7.02 (**<.001**) | -7.34 (-9.48, -5.20) | -6.72 (**<.001**) |
| STAI state (0–60) | | | | |
| Relaxation | -4.54 (-6.77, -2.31) | -4.00 (**<.001**) | -0.08 (-2.56, 2.40) | -0.06 (.950) |
| MBP+VR | -5.13 (-7.09, -3.17) | -5.13 (**<.001**) | -6.50 (-8.75, -4.26) | -5.68 (**<.001**) |
| MBP | -6.74 (-8.82, -4.66) | -6.74 (**<.001**) | -7.82 (-10.16, -5.47) | -6.52 (**<.001**) |
| PANAS balance (-40–+40) | | | | |
| Relaxation | 3.40 (1.28, 5.53) | 3.14 (**.002**) | 2.02 (-0.37, 4.41) | 1.65 (.098) |
| MBP+VR | 6.53 (4.62, 8.45) | 6.68 (**<.001**) | 8.00 (5.77, 10.24) | 7.02 (**<.001**) |
| MBP | 5.76 (3.79, 7.73) | 5.74 (**<.001**) | 7.66 (5.41, 9.91) | 6.67 (**<.001**) |
| UWES (0–102) | | | | |
| Relaxation | 0.84 (-1.26, 2.93) | 0.78 (.433) | 1.55 (-0.99, 4.10) | 1.20 (.232) |
| MBP+VR | 4.34 (2.42, 6.25) | 4.34 (**<.001**) | 4.46 (2.11, 6.81) | 3.72 (**<.001**) |
| MBP | 3.10 (1.11, 5.09) | 3.10 (**.002**) | 7.90 (5.50, 10.30) | 6.46 (**<.001**) |
| MBI (0–90) | | | | |
| Relaxation | -1.28 (-3.11, 0.56) | -1.36 (.174) | 1.45 (-0.86, 3.76) | 1.23 (.218) |
| MBP+VR | -3.09 (-4.73, -1.45) | -3.69 (**<.001**) | -2.43 (-4.57, -0.29) | -2.22 (**.026**) |
| MBP | -3.58 (-5.30, -1.87) | -4.09 (**<.001**) | -6.14 (-8.33, -3.95) | -4.09 (**<.001**) |
| ERQ reappraisal (6–42) | | | | |
| Relaxation | 0.86 (-0.53, 2.26) | 1.21 (.227) | 0.53 (-1.02, 2.08) | 0.67 (.502) |
| MBP+VR | 1.19 (-0.05, 2.42) | 1.88 (.060) | 2.10 (0.74, 3.45) | 3.04 (**.002**) |
| MBP | 2.72 (1.42, 4.03) | 4.09 (**<.001**) | 2.85 (1.46, 4.24) | 4.01 (**<.001**) |
| ERQ suppression (4–28) | | | | |
| Relaxation | -0.27 (-1.13, 0.59) | -0.61 (.540) | -1.63 (-2.61, -0.65) | -3.26 (**.001**) |
| MBP+VR | -1.44 (-2.20, -0.67) | -3.67 (**<.001**) | -2.83 (-3.72, -1.93) | -6.20 (**<.001**) |
| MBP | -1.84 (-2.64, -1.04) | -4.52 (**<.001**) | -3.10 (-4.01, -2.18) | -6.65 (**<.001**) |
| **Mechanistic outcomes** | | | | |
| FFMQ (39–195) | | | | |
| Relaxation | 6.16 (2.39, 9.93) | 3.20 (**.001**) | 6.60 (2.60, 10.60) | 3.23 (**.001**) |
| MBP+VR | 13.35 (10.12, 16.57) | 8.11 (**<.001**) | 19.06 (15.50, 22.62) | 10.50 (**<.001**) |
| MBP | 15.35 (11.84, 18.86) | 8.58 (**<.001**) | 16.91 (13.17, 20.66) | 8.86 (**<.001**) |
| SCS (26–130) | | | | |
| Relaxation | 4.36 (1.20, 7.52) | 2.70 (**.007**) | 3.84 (0.52, 7.17) | 2.27 (**.023**) |
| MBP+VR | 12.28 (9.51, 15.06) | 8.67 (**<.001**) | 16.27 (13.35, 19.19) | 10.93 (**<.001**) |
| MBP | 13.20 (10.27, 16.12) | 8.85 (**<.001**) | 13.12 (10.12, 16.13) | 8.56 (**<.001**) |

***Note:*** MBP+VR = group mindfulness-based programme training plus individual mindfulness virtual reality training. MPB = group mindfulness-based programme training only. Relaxation = group relaxation therapy training.