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Abstract

Objectives: This study was designed to test whether a brief mindful yoga intervention can prevent depression-related responses to dysphoric events.

Methods: One-hundred-75 undergraduate participants were assigned to one of four conditions in a single-session study. Three conditions received a dysphoric affect induction. Before the induction, participants completed a 20-minute intervention consisting of (a) mindful yoga, (b) stretching, or (c) relaxation control. The fourth condition consisted of a neutral affect induction to examine the validity of the dysphoric affect induction. We hypothesized that compared to relaxation control and stretching, mindful yoga participants would show less: (H1) state depressed affect; (H2) rumination; and (H3) attentional bias toward depression-related words.

Results: Validity checks indicated that the dysphoric affect induction led to greater state depressed affect and rumination, but not attentional bias. Compared to relaxation control, mindful yoga did not show less state depression, rumination, or attentional bias. The stretching group showed less depression and rumination.

Conclusions: The results do not provide support for mindful yoga in preventing depression-related reactivity. It may be that when given in a brief, one-time dose, stretching is the better choice for preventing negative outcomes from a subsequent dysphoric experience.

Keywords

Rumination, depression, yoga, attentional bias, prevention

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Introduction

Depression and its prevention

Depression is a widespread problem with an estimated lifetime prevalence of 12% (Kessler et al., 2009). A recent meta-analysis of epidemiological studies showed that a large percentage (30–40%) of individuals develops a depressive episode before the age of 25, with 19.5 years being the peak age of onset (Solmi et al., 2022). College students seem to be especially at high risk for developing depression, with a 2019 survey showing that 45.1% of college students reported feeling so depressed that it was difficult to function over the last 12 months (American College Health Association, 2019). Depression is associated with impaired functioning across a wide range of areas, including work, household, and relationships (Hammer-Helmich et al., 2018). Further, it is estimated that 30% of patients develop a chronic disorder after their first episode (Penninx et al., 2011). Having an earlier age of onset of depression is associated with a range of problems such as more impairment in social and occupational functioning, more lifetime depressive episodes, and greater symptom severity (Zisook et al., 2007). Given these data, it is important to develop effective strategies not only to treat acute symptoms but also to prevent the initial occurrence of depression, especially in college students as they are at high risk for developing depression.

Little research has examined the effects of interventions on preventing depression onset. Existing interventions for the prevention of the onset of depression in adults have shown mixed results. Buntrock et al. (2016) found that an eHealth intervention reduced the incidence of major depressive disorder (MDD) over 12 months when compared to enhanced usual care and Dam et al. (2007) showed that although a CBT intervention lowered acute depression symptoms, it did not prevent the onset of a depressive disorder.

Underlying mechanisms involved in depression prevention

One strategy for intervention development is to target mechanisms that contribute to the disorder (Strauman & Merrill, 2004). Rumination represents one such mechanism for depression. Rumination involves perseverative thinking about unpleasant feelings and problems and is proposed to contribute to depression by prolonging and exacerbating distress, thereby increasing the likelihood that initial symptoms extend over time and spiral into a depressive episode (Nolen-Hoeksema et al., 2008). This idea is supported by findings that self-report measures of rumination predict the onset of depression (Hasegawa et al., 2018; Young & Dietrich, 2015).

Like rumination, depression-related attentional bias (AB) represents excessive engagement with negative self-related information. A common measurement of AB consists of attentional probe tasks, in which two stimuli (one neutral and one disorder-relevant) are presented at different locations on a computer screen. AB is inferred by reaction time to the probe appearing in the location where one of the stimuli has been displayed. Among the commonly used probe tasks, the adapted version of the exogenous cuing task (ECT; Posner, 1980) has been increasingly used to assess AB (e.g., Elgersma et al., 2018; Koster et al., 2005).

Research with the ECT has found that depressed individuals show more AB for negative stimuli than non-depressed individuals (Leyman et al., 2007), though a recent large-scale trial did not find AB for negative words in participants who were currently depressed (but did find A for negative words in participants with remitted MDD; Elgersma et al., 2019). Further, previous research has found depression-related AB to be associated with slower mood recovery from a depressed mood induction in individuals with MDD (Clasen et al., 2013). In the aforementioned studies, the relation between depression-related AB and depression has generally been found with longer presentation times of the affective stimuli (>1000 ms), suggesting a difficulty disengaging from negative stimuli (Clasen et al., 2013; Elgersma et al., 2018; Koster et al., 2005; Leyman et al., 2007). In sum, these initial findings suggest that rumination and, to a lesser degree, depression-related AB, may represent risk factors for developing depression and thus represent potential treatment targets for interventions to prevent depression.

Yoga interventions for preventing depression onset

Yoga interventions hold promise for preventing depression onset. Yoga originated in India as a philosophical system and practice and is mostly practiced in the form of *hatha* yoga, consisting of yoga postures, breathing and meditation practices (Anderson & Sovik, 2000; Iyengar, 1979). *Hatha* yoga is a form of moderate anaerobic exercise. Anaerobic exercise has been shown to be associated with improvement in symptoms of depression (Chan et al., 2019). The potential benefits of moderate exercise on mechanisms of depression are shown in one study with college student participants, with the finding that AB toward unpleasant emotional stimuli was improved after moderate intensity but not high intensity exercise (Tian & Smith, 2011). The cultivation of mindful awareness is also part of *hatha* yoga. Mindfulness interventions have been found to be associated with decreased depressed affect (Broderick, 2005; Johnson et al., 2015), decreased rumination (Deyo et al., 2009; Jain et al., 2007), and decreased depression-related AB (Verhoeven et al., 2014). Further, yoga may represent a particularly good

method for developing mindfulness, as research has shown that such training is associated with greater increases in mindfulness compared to other practices such as sitting meditation and body scan (Carmody & Baer, 2008). Given the benefits of anaerobic exercise and mindfulness on depressed affect and the mechanisms of rumination and AB, yoga, and especially mindful forms of yoga, should have promise in reducing rumination and AB, thereby preventing the onset of a depressive disorder.

Indeed, there is evidence that yoga can decrease rumination, compared to a control group of psychoeducation (Kinser et al., 2014), or a control group of walking (Schuver & Lewis, 2016). However, other research did not find yoga effects on rumination when compared to a health education control (West et al., 2021) or treatment as usual (Vollbehr et al., 2022). Yoga interventions have been found to decrease symptoms of depression in young adults, when compared to a no-intervention control group (Falsafi, 2016; Woolery et al., 2004), but not when compared to an active control consisting of a mindfulness intervention (Falsafi, 2016). With no-intervention control studies, it is difficult to know how much of the benefits are due to the yoga-specific elements of the intervention. For example, a meta-analysis found meditation interventions to be more effective than control when using inactive forms of control, but not when using active treatment as control (Goyal et al., 2014). Similar findings are at hand for yoga interventions, which were found to be effective when compared to psychoeducation control, but not when compared to active control interventions or treatment as usual (Vollbehr et al., 2018). Moreover, existing yoga-intervention research is oftentimes criticized due to methodological shortcomings such as unclear description of the intervention, lack of rater blinding and small sample sizes (Vollbehr et al., 2018).

In sum, the above review suggests that yoga may have beneficial effects on the prevention of depression onset by targeting rumination and depression-related AB. However, many studies are plagued by methodological shortcomings, oftentimes no strong control interventions are used, and no studies investigating the preventive effects of yoga have been conducted yet. From this it becomes clear that more research is needed, including a strong control intervention in order to determine the specific effects of a yoga intervention.

Current study

As a first step in testing the promise of yoga as a preventive treatment, the current study was designed to examine whether a mindfulness-based yoga intervention would help to prevent depressive response after an experimental dysphoric affect induction.

Meditation researchers have recommended using several types of control condition, including one that closely

matches the target intervention (Davidson & Kaszniak, 2015). We followed this recommendation by including two types of control groups. Our first control condition consisted of listening to an audiobook, controlling for nonspecific factors only, whereas the second control group consisted of stretching. This control intervention consisted of yoga postures without the yoga-specific ingredients such as focusing on the breath, moving with the breath, having a short meditation at the start and the end of the intervention and without the cues intended to develop mindful awareness of body and breath and encourage acceptance. This condition was created so that we could control for the influence of the poses/physical activity on the outcome variables, thereby increasing confidence that potential group differences were the result of the yoga-specific ingredients and mindfulness instructions. A stretching intervention as control has previously been used in yoga studies (Brinsley et al., 2022; Follador et al., 2019). To test the effectiveness of the dysphoric affect induction to increase negative affect, rumination, and AB, we also included a neutral affect induction condition.

We conducted this study to test whether individuals who have been practicing mindful yoga show more resilience in response to a depression-related negative event, operationalizing resilience as less depressed affect, rumination, and depression-related AB. Specifically, we hypothesized that, compared to relaxation control and stretching, mindful yoga participants would show less influence of a subsequent dysphoric affect induction on: (H1) a state measure of depressed affect; (H2) rumination about the content of the dysphoric affect induction; and (H3) AB toward depression-related stimuli.

Method

Participants

175 undergraduate students (106 females, 61%) from the University of Groningen Psychology Department participated as partial fulfillment of a class requirement. Participants were mostly German ($n = 113$) or Dutch ($n = 42$). Mean age was 20.4 years ($SD = 1.89$; range 18–30).

Interventions

All interventions lasted 20 minutes and were presented as being designed for relaxation.

Mindful yoga. The first author (NKV, a *Registered Yoga Teacher 200* with over 10 years of yoga experience and 2 years of teaching experience) instructed the mindful yoga sessions. The intervention consisted of guided instructions through several yoga postures (see Online [Supplementary Materials 1](#)). In order to manipulate the two main facets of

mindfulness—awareness and a nonjudgmental and accepting attitude (Bishop et al., 2004), we used specific mindfulness instructions in the mindful yoga intervention. To encourage awareness, the instructor repeatedly prompted participants to focus their attention to experiences in the present moment (e.g., breath or body sensations) and to notice if their attention was wandering away from the present moment and bring it back to a present moment experience. To encourage a nonjudgmental, accepting attitude, the instructor repeatedly prompted participants to avoid self-judgment regarding their practice (e.g., emphasizing there is no ideal way to hold the posture, etc.) and to encourage self-compassion (e.g., encouraging participants to not go beyond their limits).

Stretching. The first author also instructed the stretching intervention, which also consisted of several yoga postures (see Online [Supplementary Materials 1](#)). The instructor refrained from mindfulness-related prompts and instead repeatedly instructed a self-evaluative perspective (e.g., encouraging participants to evaluate how they were doing) and instructed participants to stay in the posture as long as possible (e.g., encouraging participants to hold the posture longer).

Relaxation control. The relaxation control condition consisted of listening (via headphones) to a 20-minute audio recording of the first chapter of *Harry Potter and the Sorcerer's Stone* (Rowling, 1998). Participants were invited to allow themselves to get relaxed and absorbed in the narrative.

Affect inductions

Dysphoric affect induction. Participants were asked to recall a specific sad autobiographical memory involving loss or failure. After writing a one-sentence description of the memory, they were instructed to imagine the memory in great detail while listening to music, a 5-minute and 30 seconds selection of the main theme from the movie *Schindler's List* (John Williams, 1993), played at three-quarters speed. Music stimuli have been shown to be valid affect elicitors (Martin, 1990) and this piece of music has been shown to induce depressed affect (Nadler et al., 2010).

Neutral affect induction. The instructions were similar to the dysphoric affect induction. Participants were asked to recall a specific memory of a neutral experience and were asked to relive that experience while listening to a 5-minute and 30 seconds selection from Debussy's *Prélude à l'après-midi d'un faune* (1956). Participants in this condition were given the same intervention as participants in the relaxation control group (listening to an

audiobook) to control for the influence of the relaxation intervention on the difference between the dysphoric and neutral affect induction.

Affect induction manipulation check. Participants completed two questions to assess how sad the memory was and how much they engaged with the memory, using a scale from 1 (*not at all*) to 5 (*very much*).

Measures

All questionnaires and computer tasks were presented in English.

State depression. Depressed affect was measured with the depression-dejection scale of the Profile of Mood States (McNair et al., 1992). Participants were asked to rate the way they were feeling at that moment on four items (sad, unhappy, hopeless, worthless) using a 5-point Likert-type scale ranging from 0 (*not at all*) to 4 (*extremely*). The scale showed good internal consistency ($\alpha = .82$ [baseline]; $.71$ [post-training]; $.80$ [post-affect induction]).

Attentional bias. The ECT was used to assess AB toward depressive stimuli. The ECT was based on Koster et al. (2005) and was programmed with the E-prime 2.0 software package. Cues consisted of 10 depression-related, 10 positive, and 10 neutral words (see Online [Supplementary Materials 2](#) for a complete description of the ECT). Internal consistency was assessed by calculating the split-half reliability for the first and second half of the ECT for each type of trial as well as for the AB scores (see “Data preparation, ECT analyses”), as recommended by Elgersma et al. (2019). The Spearman–Brown correlations were high for all trial types, ranging from 0.70 (depressive/valid) to 0.78 (depressive/invalid), indicating good internal consistency. The Spearman–Brown correlations were low for the AB scores, ranging from -0.03 to -0.014 .

Rumination task. Self-reported rumination about the sad (or neutral) memory was assessed in a two-part task. First, participants were invited to sit quietly and relax (for 3 minutes). Next, participants rated the extent to which they thought about their memory during the rest period. Participants used a 100-mm visual analog scale (0 = *not at all*, 100 = *very often* [question 1] or *very much so* [questions 2–4]) to rate the extent to which they (i) experienced images or thoughts of the memory, (ii) thought about the memory event in terms of why it occurred, (iii) thought about the memory event in terms of wishing it had not happened, and (iv) thought about the memory event in terms of wondering why they reacted the way they did. A mean total rumination score was calculated, which showed good internal consistency ($\alpha = .80$).

Baseline depression. Recent symptoms of depression were assessed with the Major Depression Inventory (Bech et al., 2001), a 12-item self-report questionnaire to assess depression symptoms. Participants rated how they felt over the past 2 weeks, on a 6-point Likert scale ranging from 1 (*never*) to 6 (*all the time*). The scale showed good internal consistency ($\alpha = .85$).

Trait rumination. Rumination was assessed with the brooding scale of the short version of the Ruminative Response Scale (Nolen-Hoeksema & Morrow, 1991). We used the brooding scale to assess the maladaptive aspect of rumination (Watkins, 2008). This 5-item self-report scale consists of reactions when feeling down, sad or depressed. Participants rated the way they respond in general, on a 4-point Likert scale ranging from 1 (*almost never*) to 4 (*almost always*). The scale showed acceptable internal consistency ($\alpha = .73$).

Intervention manipulation check. We used three items to assess state mindfulness: “During the exercise...” (1) “I could focus on my own experience,” (2) “I was aware of what was going on in my body”; and (3) “After the exercise I was able to accept myself for who I am.” The first two items assessed the awareness aspect of mindfulness and the last item assessed the nonjudgmental, accepting attitude aspect. Our plan was to aggregate the awareness items, but due to a low Cronbach’s alpha of 0.56, we examined the items separately in the analyses. In addition, we used three questions to assess whether participants were comparing, pusing or evaluating themselves. Further, we used three questions to assess the credibility of the interventions. Finally, in order to address the possibility that the instructor’s expectations might influence the outcomes (Munder et al., 2012), we administered two questions to assess participants’ perception of the instructor’s expertise in and enthusiasm for the interventions. See Online Supplementary Materials 3 for a full description of these questions. Participants rated these questions on a Likert scale ranging from 1 (*not at all*) to 5 (*extremely*).

Procedure

The study consisted of a single 60-minute session. Each session was pre-assigned (without participants’ knowledge) to one of four conditions: mindful yoga ($n = 43$), stretching ($n = 41$), relaxation control ($n = 45$), all three with dysphoric affect induction, and neutral affect control ($n = 46$). Groups consisted of one to four participants. Participants were seated at individual workstations. An overview of the study procedure is shown in Figure 1.

After providing informed consent, participants completed baseline measures. Participants in the mindful yoga and stretching conditions were instructed to move to a yoga mat. Participants in the relaxation control and neutral affect control conditions remained at their workstation. After the

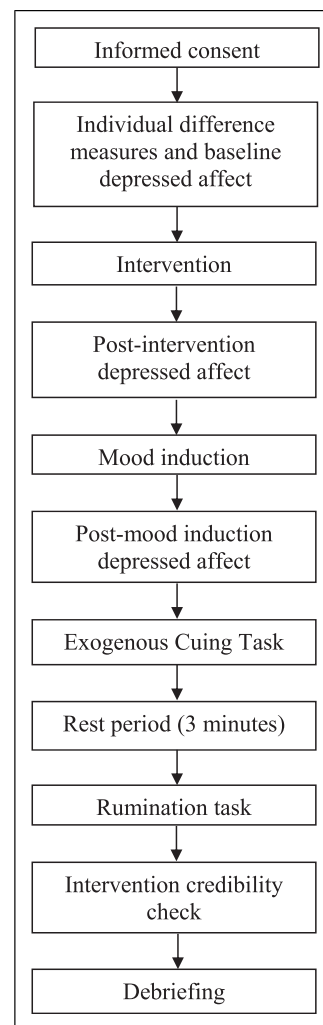


Figure 1. Study procedure.

intervention, participants completed the post-training affect ratings, the affect induction, the post-affect induction affect ratings plus the affect induction manipulation check items. Participants then completed the ECT and rumination task. All study elements were administered by the researcher (NKV or a research assistant). At the end of the study, participants completed an affect repair task (reading a humorous story) and the intervention manipulation check questions before being debriefed.

Statistical analyses

We aimed for a sample of 40 participants per group, using $\alpha = .05$, providing power of 14% to detect small, 60% to detect medium, and 94% to detect large effect-size differences. Based on previous research of exercise interventions for reducing symptoms of depression in an undergraduate sample, we expected a medium-large effect size (Huang et al., 2023; Lin

et al., 2022). We were able to recruit 175 participants. Data from 11 participants were excluded, leaving 164 participants for the analyses. Power analysis using G*Power (version 3.1.9.7; Faul et al., 2007) indicated that the current sample size with three conditions provided a statistical power of 25% to detect small effect-size differences, 89% to detect medium effect-size differences, and 100% to detect large effect-size differences between conditions.

All analyses were performed in IBM® SPSS® Statistics, version 25. The analysis plan consisted of two steps. First, as a manipulation check, we examined the effectivity of the dysphoric affect induction by testing whether compared to neutral affect control, relaxation control (using the dysphoric affect induction) demonstrated stronger state depressed affect, more depression-related AB, and more rumination. These (manipulation) effects were tested with AN(C)OVAs (using post-intervention state depression as a covariate for the depressed affect analyses). Second, we used AN(C)OVAs (with post-intervention state depression as a covariate for the depressed affect analyses) to test the main hypotheses that compared to relaxation control and stretching, participants in mindful yoga would demonstrate (H1) less state depressed affect after the dysphoric affect induction, (H2) less rumination about the dysphoric content of the dysphoric affect induction, and (H3) less depression-related AB.

Data preparation

All analyses. Data from seven participants were excluded from all analyses for the reason of indicating the sad memory was “not at all sad,” or that they did “not at all” engage with the memory during the affect induction (mindful yoga $n = 2$; relaxation control $n = 5$). Data from four additional participants were also not included (for reasons, see Online Supplementary Materials 4, Table S2), remaining 164 participants for analyses (39 in mindful yoga, 40 in stretching, 39 in relaxation control, and 46 in neutral affect control).

Rumination analyses. Data from six participants were not included in the rumination analyses (for reasons, see Online Supplementary Materials 4, Table S3). Data from participants who were not administered the ECT (see section below, $n = 7$) were also excluded, as the time between the affect induction and rumination task was notably shorter than for the other participants (i.e., the ECT took 10–15 minutes to complete). We included a remaining 150 participants for analyses (38 in mindful yoga, 40 in stretching, 36 in relaxation control and 36 in neutral affect control). As we found a non-normal distribution of the data, the rumination scores were log-transformed. After transformation, visual inspection indicated that the residual scores showed a normal distribution.

ECT analyses. Data from nine participants were not included in the ECT analyses (for reasons, see Online Supplementary Materials 4, Table S4), leaving 152 participants for analyses (38 in mindful yoga, 40 in stretching, 37 in relaxation control, and 37 in neutral affect control).

Trials with incorrect responses were removed before the analyses. After visual inspection of the data, as recommended by Koster et al. (2005) and in line with previous studies (Elgersma et al., 2018, 2019), RTs <200 ms and RTs >1000 ms were excluded as anticipatory responses and distractions. A total of 97.30% of data were used in the analyses. Median RTs were generated per individual and per type of trial. We followed previous studies (Elgersma et al., 2018, 2019) using RT-based performance measures in using the median, as it is a simple and robust way of dealing with potential outliers.

We calculated a general AB score for depression, as recommended by Mogg et al. (2008) and used in previous studies (Elgersma et al., 2019), using the following formula:

$$\text{AB depression score} = (\text{mean RT invalid/depressive cue} - \text{mean RT valid/depressive cue}) - (\text{mean RT invalid/neutral cue} - \text{mean RT valid/neutral cue})$$

The general AB was thus scored such that larger values indicate relatively greater depression-related AB.

As recommended in similar studies (Elgersma et al., 2019), scores deviating more than 3 *SDs* from the group mean were considered outliers. We found three outliers (two in mindful yoga, one in neutral affect control). We conducted analyses with and without these outliers.

Results

Sample characteristics

Table 1 shows the demographic and baseline characteristics of all groups. Correlations among the study variables are shown in Online Supplementary Materials 5.

Validity of affect induction task

To confirm that the dysphoric affect induction elicited in depression-related outcomes, we examined depression-related variables for the relaxation control (using the dysphoric affect induction) and neutral affect control groups. An ANCOVA using post-training state depression as a covariate showed a significant difference on state depression after the affect induction between relaxation control ($M = 5.21$, $SE = 0.38$) and neutral affect control ($M = 1.24$, $SE = 0.35$), $F(1.82) = 59.33$, $p < .001$, Cohen's $d = 1.47$, 95% *C.I.* [0.98, 1.94]. An ANOVA showed that, after the affect induction, participants in the relaxation control condition showed higher scores on the rumination task ($M = 1.40$, $SE = 0.14$) than participants in the neutral affect control condition ($M = 0.92$, $SE = 0.14$), $F(1.71) = 6.37$, $p = .014$, Cohen's $d = 0.58$, 95% *C.I.* [0.11, 1.05]. An

Table 1. Participant demographics as function of condition.

Variable	Mindful Yoga (<i>n</i> = 39)	Stretching (<i>n</i> = 40)	Relaxation Control (<i>n</i> = 39)	Neutral Affect Control (<i>n</i> = 46)
Mean (<i>SD</i>)				
Age	20.92 (1.88)	19.97 (1.63)	20.46 (2.23)	20.22 (1.76)
Gender, <i>n</i>				
Male	17	14	14	17
Female	22	27	26	29
Nationality, <i>n</i>				
German	24	21	27	33
Dutch	9	16	9	7
Other	6	4	4	6
Native language, <i>n</i>				
German	23	18	27	33
Dutch	9	16	7	5
English	4	2	2	3
Other	3	5	4	5
Mean (<i>SD</i>)				
MDI score	14.02 (7.47)	11.97 (7.26)	12.41 (5.88)	13.02 (8.15)
RRS score	11.08 (2.90)	10.83 (3.11)	10.74 (2.65)	10.85 (3.33)

MDI = Major Depression Inventory; RRS = Ruminative Response Scale, brooding scale.

additional ANOVA showed that, after the affect induction, participants in the relaxation control condition did not show higher depression-related AB ($M = -17.16$, $SE = 4.23$), compared to neutral affect control condition ($M = -12.45$, $SE = 4.07$), $F(1.75) = 0.64$, $p = .425$. In sum, these results provide evidence that the affect induction was indeed effective in eliciting depressed affect and depression-related rumination (but not depression-related AB).

In addition, we examined whether the three dysphoric affect induction groups followed the affect induction instructions. Results from *t*-tests indicated that the three groups had similar experiences with no group differences in the extent to which the memory was rated as being sad or the extent to which participants were engaged with the memory during the task ($ps > .269$).

Intervention manipulation check

Intervention manipulation checks are shown in Table 2. Results were in line with our expectations by indicating that, compared to relaxation control, mindful yoga produced a focus on the participants' own experience (Cohen's $d = 0.60$), and an awareness of what was going on in their bodies (Cohen's $d = 1.02$). However, this was also the case for stretching (Cohen's d 's = 0.36 and 0.71, respectively). Contrary to our expectations, mindful yoga participants reported less of an accepting attitude toward themselves compared to stretching (Cohen's $d = 0.47$). Also contrary to our expectations, not only stretching but also mindful yoga produced an evaluation of how well they were doing compared to other people in the group (Cohen's d 's =

0.54 and 1.03). In line with our expectations, compared to participants in the relaxation control condition, stretching participants demonstrated an evaluation of whether they were doing the best they could (Cohen's $d = 1.42$), and pushing themselves as far as they could go (Cohen's $d = 1.39$). Compared to relaxation control, both mindful yoga and stretching groups reported that the instructor (i) was capable (Cohen's d 's = 0.94 and 1.14) and (ii) seemed to think the exercise was useful (Cohen's d 's = 0.94 and 0.79). There were no differences between the mindful yoga and stretching groups on instructor ratings. However, in the mindful yoga group fewer participants indicated that they followed the instructions, compared to participants in the stretching group (Cohen's $d = 0.48$). In sum, these results show that mindful yoga partly led to the intended effects (e.g., more awareness), but also led to effects that we expected to be influenced only by stretching (e.g., more self-evaluation) and similarly that stretching partly led to intended effects (e.g., pushing themselves), but also led to effects that we expected to be changed only by mindful yoga (e.g., more acceptance).

Main hypotheses

The three groups that received the dysphoric affect induction were used for testing the hypotheses.

(H1) *state depression*. Table 3 shows mean state depression scores for the three groups at the three different time points of the study and Figure 2 (top) shows estimated marginal means. Inconsistent with our hypothesis, an ANCOVA

Table 2. Manipulation check per group.

Statement	Condition			F (2, 117) and p-value
	Mindful yoga (n = 39)	Stretching (n = 40)	Relaxation control (n = 39)	
Focus on own experience	4.08 (0.74) ^a	3.88 (0.94) ^{a,b}	3.49 (1.19) ^b	3.702, .028
Awareness of what was going on in body	4.18 (0.64) ^a	3.95 (0.96) ^a	3.15 (1.27) ^b	11.547, <.001
Accepting myself for who I am	3.13 (1.17) ^a	3.65 (1.03) ^b	3.46 (1.10) ^{a,b}	2.273, .108
Comparing to other people in group	1.67 (0.81) ^a	2.13 (0.99) ^b	1.28 (0.61) ^c	10.521, <.001
Evaluating whether doing the best I can	2.69 (1.24) ^a	3.78 (1.07) ^b	2.15 (1.23) ^a	19.355, <.001
Pushing as far as I can go	2.82 (0.94) ^a	4.08 (0.97) ^b	2.56 (1.21) ^a	23.633, <.001
Useful for creating relaxation	4.03 (0.81) ^a	3.73 (1.10) ^{a,b}	3.41 (1.29) ^b	3.114, .048
Liked doing the exercise	3.92 (1.01) ^a	3.93 (1.24) ^{a,b}	3.46 (1.25) ^{a,b}	2.124, .124
Followed the instructions	4.64 (0.63) ^a	4.88 (0.33) ^b	4.62 (0.59) ^a	2.865, .061
Presenter was capable	4.79 (0.47) ^a	4.88 (0.43) ^a	4.15 (0.84) ^b	17.703, <.001
Presenter seemed to think the exercise is useful	4.64 (0.49) ^a	4.58 (0.71) ^a	3.90 (1.00) ^b	11.488, <.001

Notes. Means that do not share a letter are significantly different. Scoring of the variables ranged from 1 to 5.

using post-training state depression as a covariate showed no significant effect of condition, $F(2,114) = 2.583, p = .08, \eta^2 = 0.04$. Post hoc ANCOVAs comparing each pair of groups (mindful yoga vs. relaxation control, mindful yoga vs. stretching, stretching vs. relaxation control), showed that, inconsistent with our hypothesis, the mindful yoga group did not show less state depression after the affect induction compared to relaxation control, $F(1,75) = 3.404, p = .069$, Cohen's $d = 0.32$, 95% *C.I.* [-0.13, 0.76], or stretching, $F(1,76) = 0.001, p = .971$, Cohen's $d = 0.15$, 95% *C.I.* [-0.29, 0.60]. Further, the stretching group reported less state depression compared to relaxation control, $F(1,76) = 4.872, p = .030$, Cohen's $d = 0.56$, 95% *C.I.* [0.10, 1.00].

(H2) *rumination*. Table 3 shows group means on the rumination measure and Figure 2 (middle) shows means per group. Inconsistent with our hypothesis, an ANOVA showed no main effect of group, $F(2,111) = 1.889, p = .156, \eta^2 = 0.03$. Additional post hoc ANOVAs, testing differences between each pair of groups separately (mindful yoga vs. relaxation control, mindful yoga vs. stretching, stretching vs. relaxation control), indicated no difference between the mindful yoga group and relaxation control, $F(1,72) = 0.163, p = .688$, Cohen's $d = 0.10$, 95% *C.I.* [-0.36, 0.55], between stretching and relaxation control, $F(1,74) = 3.458, p = .067$, Cohen's $d = 0.43$, 95% *C.I.* [-0.03, 0.88], or between mindful yoga and stretching, $F(1,76) = 1.955, p = .166$, Cohen's $d = 0.31$, 95% *C.I.* [-0.14, 0.76].

(H3) *attentional bias*. The AB hypothesis was tested both with the ECT outliers included and omitted. Table 3 includes outliers and shows mean reaction times per type of trial on the ECT and total scores on the AB measures per group. Figure 2 (bottom) includes outliers and shows mean

depression-related AB scores per group. Including outliers, the results of an ANOVA showed a significant difference between the three groups, $F(2,112) = 5.949, p = 0.004, \eta^2 = 0.10$. Subsequent pair-wise comparisons (mindful yoga vs. relaxation control, mindful yoga vs. stretching, stretching vs. relaxation control) showed, inconsistent with our hypothesis, a significantly larger depression-related AB in the mindful yoga group than in the relaxation control group, $F(1,73) = 6.196, p = .015$, Cohen's $d = 0.57$, 95% *C.I.* [0.11, 1.03]. When removing outliers, this significant difference remained present, $F(1,71) = 4.104, p = .047$. With outliers included, the results showed no significant difference between the mindful yoga group and stretching, $F(1,76) = 0.337, p = .563$, Cohen's $d = 0.13$, 95% *C.I.* [-0.57, 0.31]. With outliers removed, this finding was maintained, $F(1,74) = 3.210, p = .077$.

Further, the analysis also, and unexpectedly, showed a significant difference between the stretching group and relaxation control, $F(1,75) = 13.119, p = .001$, Cohen's $d = 0.83$, 95% *C.I.* [0.35, 1.28], with the stretching group showing stronger depression-related AB than the relaxation control group. There were no outliers in these two groups.

Discussion

Mindful yoga failed to prevent depressive reactivity

This study examined the effects of mindful yoga in preventing depressed affect, rumination, and depression-related AB after a dysphoric affect induction in a sample of undergraduate students. None of the main hypotheses were supported. Results showed that, compared to both a stretching and a relaxation control condition, mindful yoga did not lead to lower levels of state depression, rumination about the dysphoric memory, or depression-related AB.

Table 3. State depression, rumination, and mean RTs for ECT trials.

State depression (mean, SD)	Condition		
	Mindful yoga (n = 39)	Stretching (n = 40)	Relaxation control (n = 39)
Baseline	2.54 (3.23)	1.55 (2.73)	1.36 (1.84)
Post-training	1.08 (1.74)	.58 (1.43)	.95 (1.67)
Post-affect induction	4.10 (3.63)	3.63 (2.31)	5.21 (3.29)
Rumination (mean, SD)	Mindful yoga (n = 38)	Stretching (n = 40)	Relaxation control (n = 36)
Post-affect induction	1.32 (.88)	1.04 (.90)	1.40 (.78)
ECT variable (mean, SD)	Mindful yoga (n = 38)	Stretching (n = 40)	Relaxation control (n = 37)
Post-affect induction			
RT depressed/valid	353.99 (53.75)	351.50 (62.52)	354.00 (62.63)
RT depressed/invalid	321.47 (68.54)	319.79 (58.95)	311.82 (53.27)
RT positive/valid	353.45 (54.54)	348.49 (64.08)	343.97 (50.60)
RT positive/invalid	319.07 (63.17)	323.49 (58.34)	316.17 (53.17)
RT neutral/valid	357.14 (62.13)	355.24 (58.46)	346.53 (53.93)
RT neutral/invalid	322.91 (57.41)	317.58 (51.69)	321.51 (54.76)
Total AB depr score	1.72 (36.50)	5.95 (27.36)	-17.16 (28.62)

Note. AB = attentional bias; depr = depression; RT = reaction time in milliseconds.

Further, the results unexpectedly pointed toward stronger depression-related AB in the mindful yoga condition compared to the relaxation control condition. These results were surprising from the perspective that, compared to relaxation control, the mindful yoga instructions lead to higher ratings of state mindful awareness, and mindfulness has been shown to be inversely related to depression-related variables (Broderick, 2005; Verhoeven et al., 2014).

Previous research has shown that yoga interventions can decrease depression in young adults (Falsafi, 2016; Woolery et al., 2004) and rumination in adults (Kinser et al., 2014; Schuver & Lewis, 2016). However, these studies all included longer interventions (five to 12 weeks), compared to our single 20-minute session. Although single-session yoga interventions have found to improve anxiety (Newham et al., 2014) and stress (Huang et al., 2013; Tong et al., 2021), we found only one study investigating the immediate effects of a yoga intervention on mood (Netz & Lidor, 2003). The findings showed no significant difference between a 90-minute yoga intervention compared to a control group of a computer class or other active interventions (swimming, dancing), which is in line with our findings. It is important to note that this study investigated the acute effects of yoga on mood, and not the preventive effects of yoga. The findings of our study do not provide support for the idea that a yoga intervention has preventive effects on state depression, rumination and depression-related AB. Our null findings do not appear to be due to an invalid affect

induction, as results indicated that, compared to a neutral affect induction, the dysphoric affect induction elicited greater state depression and rumination, though not stronger depression-related AB.

One potential reason for the nonsignificant findings in the current study is indicated by the manipulation check results, which showed that although the mindful yoga participants reported greater self-awareness (the first element of mindfulness), they did not report greater self-acceptance (the second element of mindfulness) when compared to relaxation control. Following the Monitor and Acceptance Theory proposed for mindfulness interventions (Lindsay & Creswell, 2017), it is possible that training individuals to increase the awareness of their experiences without a concomitant increase in acceptance could actually increase affective reactivity. That is, our single-session mindful yoga intervention may have been effective in increasing internal awareness, but was not effective in increasing a nonjudging attitude that could help with regulating depression symptoms in response to the dysphoric event. Indeed, this idea is supported by research in mindfulness interventions, for instance in a study showing that over the course of a mindfulness intervention, participants develop greater awareness faster than nonjudging acceptance (Baer et al., 2012). The ability to monitor one's experiences has also been found to be associated with psychological distress in student samples, especially for individuals who score high on monitoring

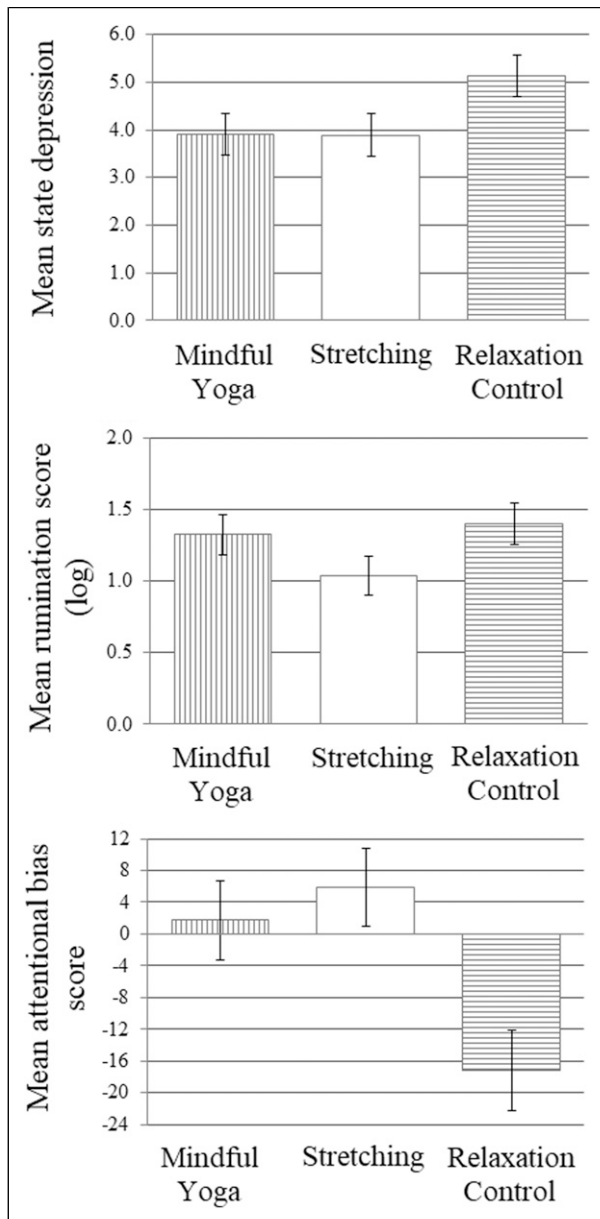


Figure 2. Condition means of post affect induction variables of state depression (top), (log-transformed) self-report rumination task (middle) and depression-related AB scores (bottom). Note. Error bars represent 1 standard error.

and low on acceptance (Hamill et al., 2015; Pearson et al., 2015). Existing research focuses on mindfulness interventions and this idea has not yet been studied in yoga interventions. Our mindful yoga intervention consisted of the combination of exercise and the developing of a mindful awareness. This might indicate that mindful yoga interventions in order to prevent depression might not have a positive effect on mood when offered in a single session. Mindful yoga interventions may need to be offered in longer trainings in order to allow participants enough time

to not only develop monitoring skills, but also acceptance skills and skills to deal with the experiences one is monitoring.

The effects of stretching on depressive reactivity

Although the mindful yoga intervention was not helpful, the study provided preliminary evidence that stretching was helpful in reducing negative affect. Compared to relaxation control, the stretching group showed less state depression after a dysphoric affect induction. These results are in line with research showing that exercise can reduce depression (Daley, 2008). Exercise may help the individual to distract from depressive thoughts, which might be the mechanism involved (Daley, 2008). However, the distracting benefits of exercise seem unlikely in our study, given that the interventions took place before the affect induction.

Although our finding that stretching may reduce dysphoric reactivity to a subsequent stressor is in line with previous research (Edwards et al., 2017; Mata et al., 2013), other studies using exercise-intervention designs have failed to find similar effects. For example, research has shown that 30-minute cycling and stretching interventions did not prevent negative mood response to a subsequent affect induction (Bernstein & McNally, 2017). In another study, there was no difference in depressed mood states following 24-minutes of cycling after a negative mood induction, compared to the same length of resting (Schmitter et al., 2023). One possible explanation for this discrepancy may involve the differing affect induction procedures. Specifically, both studies (Bernstein & McNally, 2017; Schmitter et al., 2023) used a movie clip to evoke sadness, whereas our study used a memory recall with music procedure. Given evidence that, compared to film clips, autobiographical imagination may lead to greater negative affect (Zhang et al., 2014), it is possible that participants in the other two studies had less negative affect to reduce. Another possible explanation for our stretching findings might be the type and modality of the exercise intervention—individual cycling in the study of Bernstein and McNally (2017) and of Schmitter et al. (2023) versus group stretching in the current study, as is it found that exercising in a group is more effective in reducing negative affect than individual exercise (Burke et al., 2006). Moreover, the stretching instructions included evaluations of the self against other group members. The manipulation check indicated that these instructions were followed, as participants in the stretching condition indicated comparing themselves with other group members. To the extent that the stretching participants evaluated themselves against group members with a downward social comparison style, they may have had more positive affect (Fuhr et al., 2015) and less reactivity to the dysphoric stressor.

Mechanisms of mindful yoga and stretching

We found no decrease in rumination in the mindful yoga group, compared to relaxation control or stretching. Results regarding exercise interventions to reduce rumination have been mixed. Some studies found decreased rumination in a group receiving exercise, compared to a control group of no intervention (Craft, 2005; Lavadera et al., 2020) or wait-list (La Rocque et al., 2021), but these studies all used extended intervention programs (8–9 weeks), used a no-intervention control group, or allowed participants to self-select their intervention (Craft, 2005). Therefore, the findings from these three studies need to be interpreted with caution. Regarding single-session exercise interventions, one study reported a decrease of rumination after a single session of exercise (Brand et al., 2018), but this was an open label study. Other studies have found no positive effects for exercise on rumination. For instance, the study by Schmitter et al. (2023) examined the effects of exercise versus resting on state rumination. The findings showed no difference on rumination between exercise and control. Potential reasons for the null findings in this study are explained in the previous section. Another study comparing an 8-week training of aerobic exercise with light-intensity stretching found no difference between these two groups on rumination after the 8 weeks (Olson et al., 2017). This null finding for rumination, again, might be due to the use of a strong control group (both interventions included exercise, either aerobic or anaerobic). These studies all investigated the acute effects of exercise on rumination, where we in our study focused on the preventive effects. Even though previous studies have found support for exercise interventions reducing rumination, the current findings do not provide support for the idea that exercise has preventive effects on rumination.

Unexpectedly, both the stretching group and the mindful yoga group showed stronger AB for depression-related stimuli than relaxation control. One possible explanation for this is that in the stretching and mindful yoga groups a habitual inclination to avoid negative stimuli was reduced. Future research would benefit from examining this possibility. Another possible explanation is that even though the AB difference between stretching and relaxation control was robust (i.e., it was maintained with and without outliers), it may be that the findings regarding more depression-related AB in the stretching and mindful yoga groups is due to the AB measure not being a valid measure of depression-related AB. This idea is supported by results showing that the depression and rumination measures showed construct validity in that both were reactive to the dysphoric affect induction, both correlated with each other, and both correlated with other trait depression-related measures, whereas the ECT was unrelated to affect induction and all depression-related measures in the study. Therefore, the

ECT used in this study may not represent a valid assessment of depression-related AB in a student sample.

Strengths and limitations

In addition to the limitations noted above regarding the short intervention and the potential invalidity of the ECT in our study, another limitation is that the power of our study was somewhat low (especially for differences of small effect sizes), which leads to risks such as failing to detect true effects and enhanced risk for chance findings. It would therefore be important for future research to use larger samples to increase the possibility of detecting smaller effects of mindful yoga and also to determine the robustness of the unexpected effect of stretching.

Another limitation regards the manipulation of state mindfulness in the mindful yoga group. We considered mindfulness a central aspect of yoga and its benefits and thus included instructions to facilitate mindfulness in the mindful yoga group. These instructions were omitted from the stretching intervention. Although the mindful yoga group demonstrated greater state mindful awareness (but not greater accepting attitude) compared to relaxation control, the mindful yoga and stretching groups did not differ on the two awareness mindfulness items and the stretching group showed more of an accepting attitude compared to the mindful yoga group. These findings suggest that our interventions may have been more similar than we intended them to be. This is in line with one other study comparing a short (30-minute) intervention of yoga postures with breathing techniques and mindfulness instructions to yoga postures without breathing techniques and mindfulness instructions (Herbert, 2021). Similar to our results, Herbert (2021) found no difference between the two groups on affect ratings and awareness of bodily signals. Such null findings in our study and in Herbert (2021) could indicate that manipulation of mindfulness in yoga interventions might be a more complex process or that 30 minutes of mindful yoga instructions are not enough to develop a mindful awareness. However, other studies comparing different types of mindfulness training (yoga, body scan, sitting meditation) found that the yoga intervention was particularly effective in increasing positive affect and decreasing difficulties in emotion regulation (Sauer-Zavala et al., 2013). In this light, it is important to note that this study did not include an intervention manipulation check, so we cannot determine whether these effects are due to the nature of the instructions, or due to the anaerobic exercise part of the yoga intervention. Finally, our manipulation check results show that, compared to the stretching group, participants in the mindful yoga group reported that they were less likely to follow the intervention instructions. It is unclear whether this finding means that the mindful yoga group found the instructions more difficult to follow or

because they were more disengaged with the instructions for some reason. This is an interesting finding which might explain why the participants in the mindful yoga group were reporting more awareness, but not acceptance after the intervention—that is, because compared to awareness, the acceptance instructions are more counterintuitive and thus more difficult to embody. We, again, refer to the Monitor and Acceptance Theory (Lindsay & Creswell, 2017), indicating that perhaps the participants were following the instructions regarding mindful awareness, but not regarding the nonjudgemental, accepting attitude. They even might have become more aware of the fact that they were not feeling very accepting of themselves and were comparing themselves to other people in the group.

Conclusion

This study failed to support the idea that mindful yoga helps prevent depression, rumination and depression-related AB after a dysphoric event in a sample of undergraduate students. It is possible that a single session of mindful yoga might not be enough (whereas a single session of stretching may be sufficient) to offer prevention for depression-related responses to a dysphoric event. We recommend several avenues of research to clarify the idea that mindful yoga can help to prevent depressive affect in young adults, including (i) the replication of this study using a larger sample to provide more power to detect potential effects and more confidence in the stability of the results, and (ii) examining the preventive benefits of mindful yoga and stretching offered in several sessions of longer duration.

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Ethics statement

The Ethics Committee of the University of Groningen Faculty of Behavioural and Social Sciences granted permission for this study.

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Data availability statement

The data that support the findings of this study are openly available in OSF at <https://osf.io/mjy6f/>.

Supplemental Material

Supplemental material for this article is available online.

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