

## Empirical Papers

# The potential mediating role of anxiety sensitivity in the impact of mindfulness training on anxiety and depression severity and impairment: A randomized controlled trial

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The benefits of mindfulness-based interventions to alleviate anxiety and depression have been supported by many studies. Given the effectiveness of mindfulness-based interventions on anxiety and depression, the underlying mechanisms need to be explored. Using a randomized waitlist-controlled design, this study investigated whether anxiety sensitivity was a potential mechanism for the impact of mindfulness training on anxiety and depression. Participants with high psychological distress were randomly assigned to an eight-week mindfulness intervention ( $N = 35$ ) or a wait-list control group ( $N = 34$ ). Before and after the intervention or corresponding waitlist period, participants completed measures of anxiety and depression severity and impairment and anxiety sensitivity. Separate mixed ANOVA demonstrated significant group (intervention vs. control group)  $\times$  time (pre- vs. post-test) interactions for anxiety sensitivity and overall anxiety severity and impairment and marginally significant interaction for overall depression severity and impairment. Moreover, simple mediation models showed that reductions of anxiety sensitivity from pre- to post-test mediated the impact of mindfulness training on changes in anxiety and depression severity and impairment. The findings suggest that anxiety sensitivity is a potential mechanism underlying the effect of mindfulness training on anxiety and depression, which provides a new perspective for the study of processes of change of mindfulness-based interventions.

**Key words:** Mindfulness, mechanisms, mediation, anxiety sensitivity, anxiety, depression.

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## INTRODUCTION

Mindfulness is commonly conceptualized as intentional and nonjudgmental awareness of present-moment experiences (Kabat-Zinn, 1994). Mindfulness-based interventions (MBIs), such as mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1982) and mindfulness-based cognitive therapy (MBCT; Segal, Williams & Teasdale, 2002), cultivate mindfulness skills through various kinds of mindfulness practices (e.g., mindful breathing, mindful walking, mindful yoga, and body scan). Previous research has demonstrated the benefits of MBIs in various fields. For example, MBIs could improve cognitive control (Incagli, Tarantino, Crescentini & Vallesi, 2020; Li, Liu, Zhang, Liu & Wei, 2018), enhance life satisfaction and happiness (Coo & Salanova, 2018; Henriksson, Wasara & Rönnlund, 2016), promote inner peace (Liu, Xu, Wang *et al.*, 2015), and even increase relationship satisfaction (Khaddouma, Coop Gordon & Strand, 2017).

In the field of mental health, MBIs could effectively decrease anxiety and depression in both clinical and non-clinical populations (Hofmann, Sawyer, Witt & Oh, 2010; Khoury, Sharma, Rush & Fournier, 2015). Given the efficacy of MBIs on anxiety and depression, studies exploring the mechanisms of MBIs are also becoming increasingly popular (Alsubaie, Abbott, Dunn *et al.*, 2017; Gu, Strauss, Bond & Cavanagh, 2015). By strengthening the mechanisms of interventions, the treatment effectiveness can be maximized and the application of interventions in real-world scenarios can be facilitated

(Kazdin, 2007). Therefore, the clarification of the mechanisms of MBIs is important.

An important predisposing factor for anxiety (and also depression) is anxiety sensitivity (AS), which is the fear of anxiety-related physical sensations because of rigid convictions that these sensations are harmful (Naragon-Gainey, 2010; Reiss & McNally, 1985). AS includes three sub-dimensions – physical, social, and cognitive concerns. Specifically, people high in physical, social, and cognitive concerns experience fear of physical consequences of anxiety (e.g., “When I feel pain in my chest, I worry that I’m going to have a heart attack”), social consequences of anxiety (e.g., “When I begin to sweat in a social situation, I fear people will think negatively of me”), and cognitive consequences of anxiety (e.g., “When I cannot keep my mind on a task, I worry that I might be going crazy”), respectively (Taylor, Zvolensky, Cox *et al.*, 2007). AS may amplify pre-existing anxiety such that people with elevated AS may interpret anxiety-related physical sensations as danger signals, thus experiencing elevated anxiety (Olatunji & Wolitzky-Taylor, 2009). Cross-sectional studies showed that individuals with various kinds of anxiety disorders had higher AS relative to nonclinical controls (Olatunji & Wolitzky-Taylor, 2009). Longitudinal studies suggested that AS predicted the onset and recurrence of anxiety disorders (Calkins, Otto, Cohen *et al.*, 2009) and the severity of anxiety symptoms prospectively (Bardeen & Daniel, 2018; Hovenkamp-Hermelink, Voshaar,

Batelaan *et al.*, 2019; Qi, Rappaport, Cecilione, Hettema & Roberson-Nay, 2019). In addition, interventions targeting AS (including psychoeducation about stress and anxiety symptoms and interoceptive exposure) have been shown to reduce obsessive-compulsive symptoms (Timpano, Raines, Shaw, Keough & Schmidt, 2016).

AS might not be specific to anxiety, because AS also increases the risk for depression (Epkins, Gardner & Scanlon, 2013). The AS cognitive concerns was especially associated with depression (Allan, Cooper, Oglesby, Short, Saulnier & Schmidt, 2018; Naragon-Gainey, 2010). Among the three dimensions of AS, cognitive concerns could predict unique variance of depressive symptoms (Olthuis, Watt & Stewart, 2014). A few studies also demonstrated the importance of physical concerns in predicting depressive symptoms. One study, for instance, showed that only physical concerns predicted increases in depressive symptoms among the three dimensions of AS (Grant, Beck & Davila, 2007). AS could prospectively predict depressive symptom severity (Qi *et al.*, 2019). Moreover, interventions targeting AS (including psychoeducation about stress and anxiety symptoms and interoceptive exposure) have found that decreased AS was associated with reduced depressive symptoms (Norr, Allan, Macatee, Keough & Schmidt, 2014).

Mindfulness emphasizes monitoring present-moment experiences in a non-judgmental and non-reactive way (Bishop, Lau, Shapiro *et al.*, 2004). This practice might attenuate AS. People high on dispositional mindfulness or those who have received mindfulness training may accept emotions and related body sensations as they occur without reactivity and judgment, while AS is fear of anxiety and physical sensations associated with it. Theoretically, non-judgmental and non-reactive awareness of anxiety and related sensations may facilitate exposure and extinction learning, which consequently leads to decreased fear of anxiety and related sensations (Baer, 2003; Brown, Ryan & Creswell, 2007). For non-clinical populations (e.g., undergraduate students), studies have demonstrated the negative relationship between dispositional mindfulness and AS (Macaulay, Watt, MacLean & Weaver, 2015). In addition, mindfulness training reduced AS among elderly people in residential care (Helmes & Ward, 2015) and university-community adults (Tanay, Lotan & Bernstein, 2012). Longitudinal studies also indicated that dispositional mindfulness prospectively and negatively predicted AS in people with posttraumatic stress disorder symptoms six months after a potentially traumatic event (Nitzan-Assayag, Aderka & Bernstein, 2015). For clinical populations, Kraemer, McLeish and Johnson (2015) found a significant association between dispositional mindfulness and AS in asthma patients. Some intervention studies also demonstrated that MBIs effectively reduced AS in patients with panic disorder (Kim, Lee, Kim *et al.*, 2010; Kim, Cho, Lee *et al.*, 2013) and generalized anxiety disorder (Alimehdi, Ehteshamzadeh, Naderi, Eftekharsaadi & Pasha, 2016).

A theoretical model proposed by Shapiro, Carlson, Astin and Freedman (2006) suggests that enhanced emotional, cognitive, and behavioral flexibility are mechanisms that explain why mindfulness is beneficial. According to the model, emotional, cognitive, and behavioral flexibility can be strengthened by objectively observing present-moment experiences without being

immersed in them. And with emotional, cognitive, and behavioral flexibility, people can respond to environmental stimuli in a non-rigid and flexible manner (Shapiro *et al.*, 2006). In contrast, AS is reflexive fear of anxiety-related physical sensations as a result of inflexible convictions that the sensations are harmful (Reiss & McNally, 1985). Thus, people with high AS lack both cognitive and emotional flexibility, which might be improved through MBIs. Therefore, AS may be one mechanism of MBIs in alleviating anxiety and depression. However, as far as we know, no research has explored whether the effect of MBIs to relieve anxiety and depression was mediated by AS.

Using a randomized waitlist-controlled design, the current study tested the potential mediating role of AS in the effect of mindfulness training to alleviate anxiety and depression among people with high psychological distress. We hypothesized that an eight-week mindfulness training would produce more reductions in anxiety and depression severity and impairment and AS relative to a wait-list control. Moreover, reductions in AS from pre- to post-test were hypothesized to significantly mediate the influence of the intervention on changes in anxiety and depression severity and impairment from pre- to post-test.

## METHOD

### *Ethical statement*

The study was approved by the Institutional Review Board of Peking University. Informed consent was gained from each participant before their participation.

### *Participants*

To gauge the sample size needed for the current study, we conducted a priori power analysis using G\*Power 3.1.9.4 software. Based on previous meta-analytic reviews (Hofmann *et al.*, 2010; Khoury *et al.*, 2015), the effect size of MBIs on anxiety and depression was expected to be moderately strong. Using an F-test, within-between interaction with two groups, two measurements, effect size  $f$  of 0.25 (medium effect size in G\*Power),  $\alpha$  error probability of 0.05, power of 0.80, and a conservative correlation of 0.50 between repeated measures, the power analysis results suggested that 17 participants for each group (34 participants in total) were needed.

Three hundred and thirty-six participants were recruited through online advertisement. Screening of eligible participants for this study was conducted. The inclusion criteria were: (1) an overall score of  $\geq 22$  on the K10 (Kessler, Andrews, Colpe *et al.*, 2002) indicating high psychological distress; (2) no previous training in MBIs, such as MBCT or MBSR; (3) no regular mind-body practices (less than 20 min per week) within the last 6 months; (4) no asthma and cardio-cerebrovascular diseases that might be worsened by mindfulness practices; and (5) a commitment for the study (including acceptance of the group assignment, no time conflicts, and no participation in other psychological interventions during the study). Exclusion criteria were: (1) a lifetime diagnosis of severe psychiatric disorders (e.g., borderline personality disorder, bipolar disorder); (2) suicidal ideation or suicide attempt within 6 months before the screening; and (3) history of substance abuse or dependence.

A total of 69 eligible participants (male: 18, female: 51; mean age = 30.84,  $SD = 7.91$ ) participated in the current study. They were randomly allocated to either the mindfulness training group or wait-list control group, with 35 participants (male: 11; female: 24) in the training group and 34 (male: 7, female: 27) in the control group. Participants in the wait-list control group received no treatment during the study and were offered a two-day mindfulness training after the ending of the study. All

Table 1. Sociodemographic characteristics of participants

	Intervention group	Wait-list control
<i>N</i>	35	34
Age	31.09 (8.24)	30.59 (7.79)
% female	68.57%	79.41%
Years of education	17.51 (1.85)	17.38 (2.45)
Household monthly income per person (Chinese Yuan)	10439.39 (8001.72)	9326.47 (8467.78)

Note: Numbers in parentheses are standard deviations.

69 participants completed the baseline assessment. One participant in the control group dropped out after the pre-test due to not accepting the group assignment. After the last session of the intervention, 33 participants in the intervention group and 31 in the control completed the post-test. Table 1 shows participants' sociodemographic characteristics. Figure 1 provides a participant flow of the study.

Measures

The Overall Anxiety Severity and Impairment Scale (OASIS): a five-point questionnaire with five items used to measure anxiety symptom severity (i.e., the frequency and intensity of anxious feelings) and impaired functioning related to anxiety symptoms (i.e., behavioral avoidance, impediments to functioning at work/school/home, and impairment of social relationship) (Norman, Hami Cissell, Means-Christensen & Stein, 2006). The scores for the five items were added together to obtain a total score, with a higher total score signifying greater anxiety symptom severity and anxiety-related impairment. The OASIS has sound psychometric properties (Norman *et al.*, 2006). The Chinese version of the OASIS in Barlow, Ellard, Fairholme *et al.* (2010/2013) was used in the current study. The Cronbach's alpha of OASIS was 0.80 for pre-test and 0.91 for post-test.

The Overall Depression Severity and Impairment Scale (ODSIS): a five-point questionnaire with five items evaluating the severity of depressive symptoms (i.e., the frequency and intensity of depressed mood) and depression-related functional impairment (i.e., impediments to work/school and social life, and functional impairments in pleasurable activities due to depression) (Bentley, Gallagher, Carl & Barlow, 2014). The scores for the five items were added together to obtain a total score, with a higher

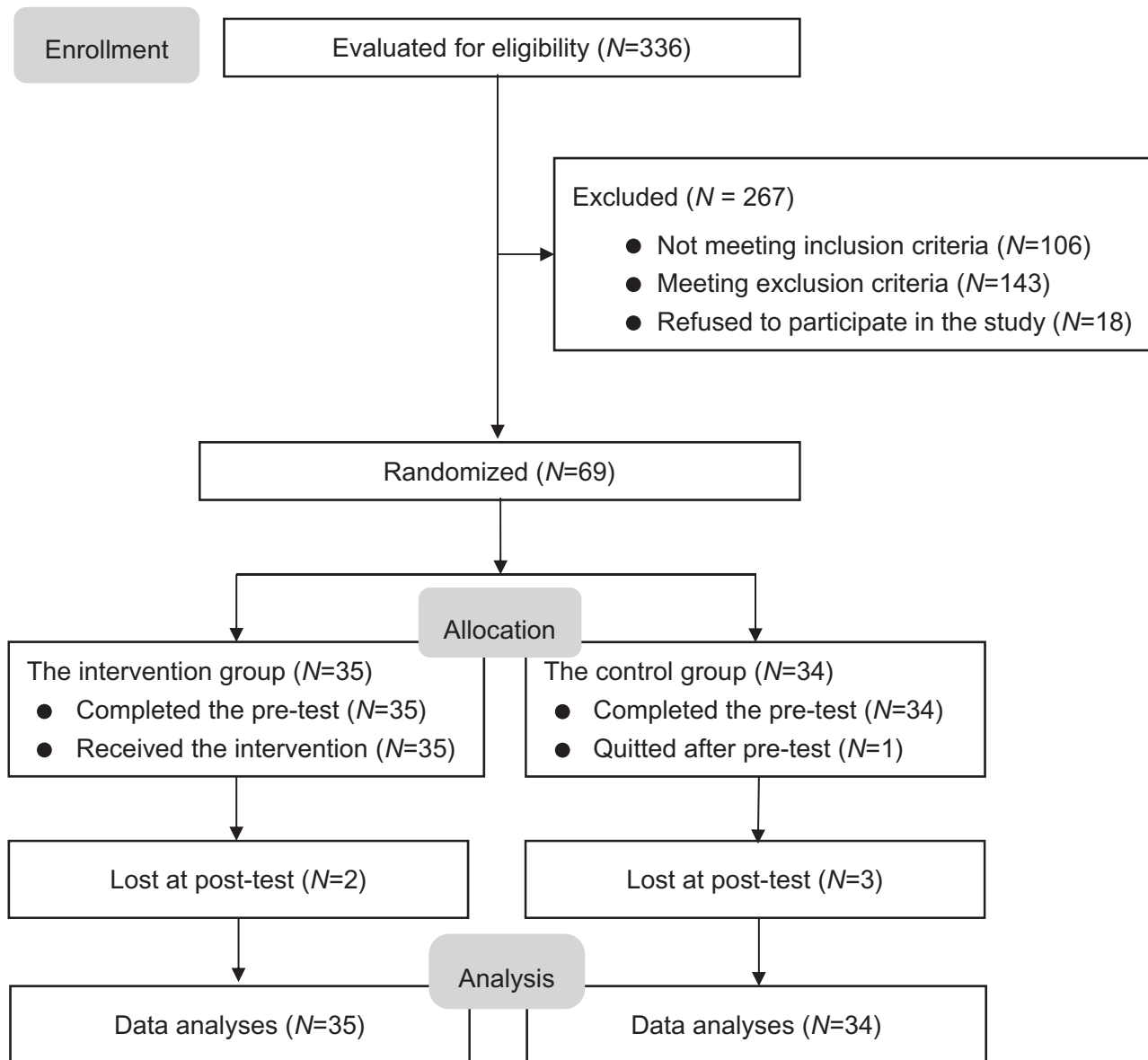


Fig. 1. Participant flow of the study.

total score indicating greater depressive symptom severity and depression-related impairment. Previous research indicated sound internal consistency and validity of the ODSIS (Ito, Bentley, Oe *et al.*, 2015). The Chinese version of the ODSIS in Barlow *et al.* (2010/2013) was used in the current study. The Cronbach's alpha of ODSIS was 0.94 for pre-test and 0.96 for post-test.

Anxiety Sensitivity Index-3 (ASI-3): a five-point scale with 18 items used to measure AS. It comprises three six-item subscales, namely, physical, cognitive, and social concerns (Taylor *et al.*, 2007). The subscale and overall scores were calculated by adding up the scores of corresponding items. Higher levels of AS and its dimensions were indicated by higher overall and subscale scores, respectively. The scale has satisfactory psychometric properties (Wheaton, Deacon, McGrath, Berman & Abramowitz, 2012). The Chinese version of this scale was translated and adapted by Wang *et al.* (2014), which, consistent with the original ASI-3, comprised of three factors and showed satisfactory reliability and validity (Cai, Dong, Pan *et al.*, 2018; Wang *et al.*, 2014). At pre-test, Cronbach's alpha values were 0.93, 0.87, 0.88, and 0.81 for the entire scale, the physical, social, and cognitive concerns subscale, respectively. At post-test, Cronbach's alpha values were 0.94, 0.91, 0.91, and 0.91 for the entire scale, the physical, social, and cognitive concerns subscale, respectively.

The 10-item Kessler Psychological Distress Scale (K10): a five-point scale with 10 items assessing psychological distress related to anxiety and depression during the past four weeks (e.g., feeling hopeless, feeling restless) (Kessler *et al.*, 2002). The scores for the 10 items were added together to obtain a total score. Therefore, the total score falls into the range of 10 ~ 50. The higher the total score, the more severe the psychological distress. The K10 has shown good internal consistency (Fassaert, De Wit, Tuinebreijer *et al.*, 2009) and a good ability to differentiate people with anxiety and mood disorders from those not (Oakley Browne, Wells, Scott & McGee, 2010). The Chinese version of this scale also demonstrated sound psychometric properties as a valid assessment of psychological distress among Chinese people (Zhou, Chu, Wang *et al.*, 2008). In this study, the K10 was utilized to screen for participants with high psychological distress. Consistent with prior studies, individuals who scored at least 22 on the K10 were considered to have high psychological distress (Byles, Robinson, Banks *et al.*, 2014; Chen, Mao, Kong *et al.*, 2016).

### Procedure

*Pre-test.* Eligible participants were randomly allocated either to the intervention or wait-list control group. During one week before the beginning of the mindfulness training, participants in both groups read and signed informed consent followed by completing a series of self-report measures, including OASIS, ODSIS, and ASI-3 used in this study.

*Eight-week mindfulness intervention program.* The program was designed based on the protocol for MBSR (Kabat-Zinn, 1990) and MBCT (Segal *et al.*, 2002). The program included eight sessions (one session per week) with 2.5-h group training for each session. The group leaders were two mindfulness teachers who had received MBSR or MBCT teacher training and had rich experiences in mindfulness practices and mindfulness teaching. Each mindfulness teacher instructed some participants in the intervention group to practice mindfulness skills. Formal mindfulness practices in this training program included: (1) mindful eating raisins (intentionally paying attention to the shape, smell, sound, and taste of raisins when eating them); (2) body scan (keeping aware of physical sensations of the body parts when scanning from head to toe); (3) sitting meditation (bringing attention to breath, thoughts, or outside sounds when sitting still); (4) walking meditation (observing the moment-by-moment sensations of the body parts in motion); and (5) mindful yoga (observing the physical sensations when stretching the body). The mindfulness teachers encouraged participants to bring an attitude of nonjudgment and non-reactivity to all practices. Participants were provided with audio recordings to practice at home and daily practice log sheets to keep track of their home practices. During group discussions, participants shared their

experiences and questions, and the mindfulness teachers provided necessary guidance.

*Post-test.* During one week after the eighth session of mindfulness training, participants in both groups completed OASIS, ODSIS, and ASI-3.

### Data analyses

Careless responding could distort factor structures of measures and weaken associations between measures (Arthur, Hagen & George, 2021). Therefore, instructed items that explicitly asked participants to select a specified answer (e.g., "Please select *strongly disagree* in this item") were incorporated into the questionnaires of the current study. The instructed items enabled us to detect participants reading or answering the questions carelessly (DeSimone, Harms, & DeSimone, 2015; Kam & Chan, 2018). At pre-test, four participants failed to respond as instructed in at least one instructed item in the test series that contained OASIS and ODSIS, and one participant failed at least one instructed item in the test series that contained ASI-3. At post-test, one participant failed to respond as instructed in at least one instructed item in the test series that contained OASIS and ODSIS, and six participants failed at least one instructed item in the test series that contained ASI-3. If participants selected wrong answers for at least one instructed item in a specific test series, participants' data in that test series was considered invalid and was removed and treated as missing values.

IBM SPSS statistics 21.0 was used for the statistical analyses in our study. An  $\alpha$  level of 0.05 was adopted to examine statistical significance. Consistent with previous studies (Brito-Pons, Campos & Cebolla, 2018; Samios, 2018; Sommers-Spijkerman, Trompeter, Schreurs & Bohlmeijer, 2018), missing data was imputed using the expectation-maximization algorithm (El-Masri & Fox-Waslyshyn, 2005).

First, bivariate Pearson correlational analyses were conducted to examine the relationship between baseline AS with baseline OASIS and ODSIS. In addition, independent-samples *t* tests and chi-square tests were computed to determine baseline equivalence between the two groups on sociodemographic data (i.e., age, gender, years of education, and household monthly income per person) and pre-test mediators (global AS and its three dimensions) and dependent variables (anxiety and depression).

If baseline group differences were found on any variables, pre-test scores on those variables were controlled for in all subsequent analyses. If not, separate two-way mixed ANOVA (between-subject variable: mindfulness training vs. wait-list control; within-subject: pre- vs. post-test) was calculated for the mediators and dependent variables. Consistent with Xu, Jia, Liu and Hofmann (2016), if the group  $\times$  time interaction was significant, simple effect analyses were run to test the time effect within each group individually. Partial eta squared ( $\eta_p^2$ ) was computed to obtain the effect sizes for interaction and simple effect analyses. Consistent with Cohen (1988),  $\eta_p^2$  values of 0.01, 0.06, and 0.14 corresponds to small, medium, and large effect size, respectively.

To determine whether the impact of mindfulness training on anxiety and depression was mediated by AS, simple mediation models were tested using Model 4 from the PROCESS Macros for SPSS (Hayes, 2013). Bootstrapping analyses with 95% confidence intervals (CIs) and 5,000 resamples were conducted. CIs that do not include zero indicate significant indirect effects. Unstandardized beta ( $\beta$ ) coefficients for the pathways linking the independent variable, mediators, and dependent variables were also reported. In the mediation models, the independent variable (IV) was mindfulness training participation (coded as 1 = mindfulness training, 0 = wait-list control), the mediators (M) were global AS and its three dimensions, and the outcomes (DV) were OASIS and ODSIS. Consistent with previous studies (Nila, Holt, Ditzgen & Aguilar-Raab, 2016; Ștefan, Căpraru & Szilágyi, 2018), all mediators and dependent variables were change scores from pre- to post-test. Specifically, to obtain the change scores of ASI-3, OASIS, and ODSIS, the pre-test scores for these scales were subtracted from the corresponding post-test scores. Therefore,

negative change scores for each scale indicated a decrease in AS, anxiety, and depression, respectively.

For sensitivity analyses, we conducted ANOVA tests and mediation analyses without removing the data of participants who failed the instructed items.

## RESULTS

### Baseline characteristics

Bivariate correlation analyses showed that baseline global AS was significantly associated with baseline OASIS ( $r = 0.25, p < 0.05$ ) and ODSIS ( $r = 0.26, p < 0.05$ ). Also, there were significant associations between cognitive concerns with OASIS ( $r = 0.30, p < 0.05$ ) and ODSIS ( $r = 0.36, p < 0.01$ ). Social concerns had a significant relationship with ODSIS ( $r = 0.25, p < 0.05$ ) and did not significantly correlate with OASIS ( $r = 0.20, p = 0.11$ ). No significant associations were found between physical concerns with OASIS ( $r = 0.18, p = 0.13$ ) and ODSIS ( $r = 0.11, p = 0.37$ ). Chi-square tests and independent sample  $t$  tests analyses showed that there were no significant differences between the intervention and control group on any sociodemographic variables or baseline measurements (all  $p > 0.05$ ).

### Treatment effect of the intervention

Separate mixed ANOVA yielded significant group  $\times$  time interactions for global AS ( $F[1, 67] = 7.42, p = 0.008, \eta_p^2 = 0.100$ ), physical concerns ( $F[1, 67] = 5.42, p = 0.023, \eta_p^2 = 0.075$ ), and cognitive concerns ( $F[1, 67] = 14.01, p < 0.001, \eta_p^2 = 0.173$ ), except for social concerns ( $F[1, 67] = 1.43, p = 0.236, \eta_p^2 = 0.021$ ). Follow-up analyses of simple effects of interactions illustrated that the intervention group showed significantly lower global AS, physical, and cognitive concerns at post-test compared with those at pre-test (global AS:  $F(1, 67) = 25.24, p < 0.001, \eta_p^2 = 0.274$ ; physical concerns:  $F(1, 67) = 13.82, p < 0.001, \eta_p^2 = 0.171$ ; cognitive concerns:  $F(1, 67) = 25.54, p < 0.001, \eta_p^2 = 0.276$ ); while within the control group, no significant differences existed between pre- and post-test in global AS, physical, and cognitive concerns (global AS:  $F(1, 67) = 1.27, p = 0.264, \eta_p^2 = 0.019$ ; physical concerns:  $F(1, 67) = 0.16, p = 0.694, \eta_p^2 = 0.002$ ; cognitive concerns:  $F(1, 67) = 0.08, p = 0.785, \eta_p^2 = 0.001$ ).

In addition, mixed ANOVA demonstrated significant group  $\times$  time interactions for OASIS and marginally significant interactions for ODSIS (OASIS:  $F(1, 67) = 5.17, p = 0.026, \eta_p^2 = 0.072$ ; ODSIS:  $F(1, 67) = 3.76, p = 0.057, \eta_p^2 = 0.053$ ). In the intervention group, follow-up simple effect analyses demonstrated that the post-test scores of OASIS and ODSIS were both lower than the pre-test scores (OASIS:  $F(1, 67) = 70.09, p < 0.001, \eta_p^2 = 0.511$ ; ODSIS:  $F(1, 67) = 15.14, p < 0.001, \eta_p^2 = 0.184$ ). Within the control group, the OASIS score at post-test was significantly lower than that at pre-test ( $F(1, 67) = 25.60, p < 0.001, \eta_p^2 = 0.276$ ), but ODSIS at post-test was not significantly different from that at pre-test ( $F(1, 67) = 1.24, p = 0.270, \eta_p^2 = 0.018$ ).

In sum, the results showed statistically significant improvements from pre- to post-test in global AS, AS physical and cognitive concerns, overall anxiety and depression severity and impairment in the mindfulness intervention group relative to the control (although the group  $\times$  time interaction for ODSIS was marginally significant, the  $p$  value of it was very close to the significance level and effect size was nearly medium). Also, the results of  $\eta_p^2$  demonstrated a large effect size for AS cognitive concerns, medium effect sizes for global AS, AS physical concerns, and OASIS, and a small (nearly medium) effect size for ODSIS, respectively. Table 2 shows the descriptive statistics results of each group at pre- and post-test and mixed ANOVA results. The results of ANOVA were supported by sensitivity analyses except that the group  $\times$  time interaction for OASIS in sensitivity analyses was marginally significant rather than significant (OASIS:  $F(1, 67) = 3.14, p = 0.081, \eta_p^2 = 0.045$ ; ODSIS:  $F(1, 67) = 2.92, p = 0.092, \eta_p^2 = 0.042$ ; global AS:  $F(1, 67) = 6.74, p = 0.012, \eta_p^2 = 0.091$ ; physical concerns:  $F(1, 67) = 5.35, p = 0.024, \eta_p^2 = 0.074$ ; cognitive concerns:  $F(1, 67) = 12.69, p < 0.001, \eta_p^2 = 0.159$ ; social concerns:  $F(1, 67) = 1.10, p = 0.298, \eta_p^2 = 0.016$ ).

### Mediation analyses

Table 3 summarizes the results of mediation analyses. The mediation models with changes in global AS being the mediator are shown in Fig. 2 and Fig. 3.

When using the change scores of the OASIS as the dependent variable, we found that the indirect effect of mindfulness training on changes in OASIS through changes in global AS, AS physical

Table 2. Descriptive statistics and mixed ANOVA results

Variable	Intervention group ( $N = 35$ )		Waitlist control group ( $N = 34$ )		Mixed ANOVA		
	Pre-test $M$ ( $SD$ )	Post-test $M$ ( $SD$ )	Pre-test $M$ ( $SD$ )	Post-test $M$ ( $SD$ )	$F$	$p$	$\eta_p^2$
AS	29.94 (15.29)	19.59 (11.87)	30.09 (14.49)	27.73 (15.95)	7.42	0.008	0.100
AS_PC	8.43 (5.85)	5.33 (4.66)	9.33 (5.66)	9.00 (6.03)	5.42	0.023	0.075
AS_CC	9.34 (4.81)	5.61 (4.40)	8.45 (4.49)	8.66 (5.54)	14.01	<0.001	0.173
AS_SC	12.17 (6.43)	8.66 (5.37)	12.31 (6.02)	10.08 (6.62)	1.43	0.236	0.021
OASIS	9.65 (3.35)	4.96 (3.21)	9.51 (2.39)	6.63 (3.17)	5.17	0.026	0.072
ODSIS	6.51 (4.27)	3.68 (3.64)	5.71 (3.98)	4.89 (4.36)	3.76	0.057	0.053

Note: AS = global anxiety sensitivity, AS\_PC = physical concerns of anxiety sensitivity, AS\_CC = cognitive concerns of anxiety sensitivity, AS\_SC = social concerns of anxiety sensitivity, OASIS = overall anxiety severity and impairment, ODSIS = overall depression severity and impairment.

Table 3. Mediating effect of anxiety sensitivity in the effect of mindfulness training on anxiety and depression

Independent variable	Mediator	Dependent variable	Effect of IV on M	Effect of M on DV	Direct effect	Indirect effect	
						(a × b)	95% CI
(IV)	(M)	(DV)	(a)	(b)	(c')	(a × b)	95% CI
Group	AS	OASIS	-8.00**	0.09**	-1.06 <sup>a</sup>	-0.75	(-1.98, -0.15)
	AS_PC		-2.77*	0.18*	-1.31 <sup>a</sup>	-0.50	(-1.56, -0.04)
	AS_CC		-3.94***	0.28**	-0.70 <sup>a</sup>	-1.12	(-2.58, -0.32)
	AS	ODSIS	-8.00**	0.18***	-0.57 <sup>a</sup>	-1.44	(-2.85, -0.51)
	AS_PC		-2.77*	0.31**	-1.14 <sup>a</sup>	-0.87	(-2.11, -0.17)
	AS_CC		-3.94***	0.52***	0.05 <sup>a</sup>	-2.06	(-3.88, -1.01)

Note: Group = mindfulness training vs. wait-list control (coded as 1 = mindfulness training, 0 = wait-list control), AS = changes in global anxiety sensitivity from pre- to post-test, AS\_PC = changes in physical concerns of anxiety sensitivity from pre- to post-test, AS\_CC = changes in cognitive concerns of anxiety sensitivity from pre- to post-test, OASIS = changes in overall anxiety severity and impairment from pre- to post-test, ODSIS = changes in overall depression severity and impairment from pre- to post-test.

\* $p < 0.05$ ;

\*\* $p < 0.01$ ;

\*\*\* $p < 0.001$ ;

<sup>a</sup>Non-significant.

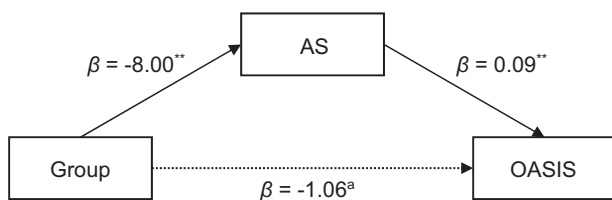


Fig. 2. Mediating effect of global anxiety sensitivity in the effect of mindfulness training on overall anxiety severity and impairment. Note. Group = mindfulness training vs. wait-list control (coded as 1 = mindfulness training, 0 = wait-list control). AS and OASIS were changes in global anxiety sensitivity and overall anxiety severity and impairment from pre- to post-test, respectively.  $\beta$  were unstandardized coefficients. \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ ; <sup>a</sup> Non-significant.

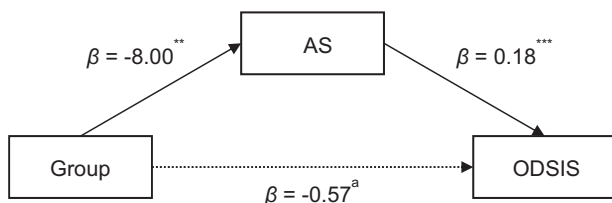


Fig. 3. Mediating effect of global anxiety sensitivity in the effect of mindfulness training on overall depression severity and impairment. Note. Group = mindfulness training vs. wait-list control (coded as 1 = mindfulness training, 0 = wait-list control). AS and ODSIS were changes in global anxiety sensitivity and overall depression severity and impairment from pre- to post-test, respectively. \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ ; <sup>a</sup> Non-significant.

concerns, and AS cognitive concerns were all significant (global AS:  $\beta = -0.75$ , 95% CI [-1.98, -0.15]; AS physical concerns:  $\beta = -0.50$ , 95% CI [-1.56, -0.04]; AS cognitive concerns:  $\beta = -1.12$ , 95% CI [-2.58, -0.32]). Since the group  $\times$  time interaction for AS social concerns was non-significant, we did not conduct a mediation analysis for it.

In terms of ODSIS, we found the indirect effect of mindfulness training on changes in ODSIS through changes in global AS, AS physical concerns, and AS cognitive concerns were all significant (global AS:  $\beta = -1.44$ , 95% CI [-2.85, -0.51]; AS physical

concerns:  $\beta = -0.87$ , 95% CI [-2.11, -0.17]; AS cognitive concerns:  $\beta = -2.06$ , 95% CI [-3.88, -1.01]). Since the group  $\times$  time interaction for AS social concerns was non-significant, we did not conduct a mediation analysis for it.

The results of mediation analyses were supported by sensitivity analyses. Specifically, the mediating effect of global AS, AS physical concerns, and AS cognitive concerns in the effect of mindfulness training on changes in OASIS (global AS:  $\beta = -0.77$ , 95% CI [-1.84, -0.09]; AS physical concerns:  $\beta = -0.57$ , 95% CI [-1.59, -0.02]; AS cognitive concerns:  $\beta = -1.06$ , 95% CI [-2.38, -0.20]) and ODDIS (global AS:  $\beta = -1.40$ , 95% CI [-2.75, -0.35]; AS physical concerns:  $\beta = -0.84$ , 95% CI [-2.01, -0.06]; AS cognitive concerns:  $\beta = -2.00$ , 95% CI [-3.54, -0.80]) were all significant.

## DISCUSSION

This study investigated whether anxiety sensitivity was a potential mechanism underlying the effect of mindfulness training on anxiety and depression severity and impairment in people with high psychological distress. We hypothesized that eight-week mindfulness training could improve anxiety and depression severity and relevant impairment and AS from pre- to post-test relative to a wait-list control. Moreover, the reductions of AS from pre- to post-test would mediate the effect of mindfulness training on anxiety and depression symptom severity and relevant impairment.

The group  $\times$  time interaction for OASIS was significant, and the group  $\times$  time interaction for ODSIS was marginally significant with a  $p$  value that was very close to the significance level and a nearly medium effect size. Although the group  $\times$  time interaction for OASIS changed from being significant to marginally significant in sensitivity analyses (i.e., without removing the data of participants who failed the instructed items), it was not surprising because careless responding could distort hypothesis testing (DeSimone & Harms, 2018). Thus, the results support our hypothesis on the effect of eight-week mindfulness training to alleviate anxiety and depression severity and relevant impairment. The results are also in accordance with previous

findings that MBIs were effective in reducing anxiety and depression (Hofmann *et al.*, 2010; Khoury *et al.*, 2015).

Moreover, previous MBI studies heavily focused on the effect on anxiety and depressive symptoms and neglected the effect on functional impairment related to anxiety and depression (Hofmann *et al.*, 2010; Khoury *et al.*, 2015). As demonstrated by previous studies, the overall correlations between anxiety and depressive symptom severity with functional impairment were only relatively low to moderate (McKnight, Monfort, Kashdan, Blalock & Calton, 2016; McKnight & Kashdan, 2009). It was also argued that functional impairment needs to be included in outcomes of anxiety and depression treatment research in addition to anxiety and depressive symptoms (McKnight *et al.*, 2016; McKnight & Kashdan, 2009). Therefore, our study also extends previous findings by using OASIS and ODSIS to investigate the effect of MBIs on symptom severity and *functional impairment* of anxiety and depression.

In addition, we found that AS decreased more within the mindfulness intervention group relative to the wait-list control. This finding supports previous evidence that mindfulness training could reduce AS in various clinical and non-clinical populations, e.g., patients with panic disorder (Kim *et al.*, 2010, 2013), patients with generalized anxiety disorder (Alimehdi *et al.*, 2016), elderly people in residential care (Helmes & Ward, 2015), and university–community adults (Tanay *et al.*, 2012). Moreover, this result extends previous findings by testing the hypothesis in a sample with high non-specific psychological distress.

The mediation analyses revealed significant indirect effect of mindfulness training on changes in overall anxiety and depression severity and relevant impairment through changes in AS, which support our hypothesis. The mediating effects found in the current study provide empirical evidence for the theoretical underpinnings of mindfulness put forward by Shapiro *et al.* (2006). Specifically, Shapiro *et al.* proposed that enhanced emotional, cognitive, and behavioral flexibility are mechanisms that account for the benefits of mindfulness practices. Individuals with high AS have a rigid cognitive style about anxiety-related physical sensations. They tend to rigidly interpret the body sensations associated with anxiety as harmful, thus they lack cognitive flexibility. In addition, they tend to reflexively fear anxiety-related physical sensations, thus they also lack emotional flexibility. Therefore, AS being a potential mechanism of MBIs supports the theoretical roles of cognitive and emotional flexibility in the effect of MBIs.

The mediation results support Kim *et al.*'s (2013) report that improvement in AS after receiving MBCT could predict remission of panic disorder one year later. However, Kim *et al.* targeted panic disorder patients, did not test a mediation model, and was non-controlled. Mindfulness training also improved AS in other clinical and non-clinical populations (Alimehdi *et al.*, 2016; Helmes & Ward, 2015; Kim *et al.*, 2010; Tanay *et al.*, 2012). However, these studies did not examine the relationship between changes in AS and changes in anxiety and depression with mindfulness training. Therefore, they could not answer the question of whether AS is a mediator in the effect of mindfulness training on anxiety and depression. To our knowledge, this is the very first study discovering that AS mediates the impact of mindfulness training on anxiety and depression. The current study provides a new perspective and offers a new candidate

mechanism for the study of mechanisms of MBIs. Moreover, based on the discovery of the critical role of AS, practitioners in the future may focus on the reduction of AS during the implementation of MBIs to maximize the effect of MBIs on anxiety and depression.

This study has several limitations. First, this study concurrently assessed AS, anxiety and depression severity and impairment at pre- and post-test without demonstrating that changes in AS precede changes in anxiety and depression severity and relevant impairment. Temporal precedence is a prerequisite to inferring causal relationships or mechanisms of change (Kazdin, 2007; Kraemer, Wilson, Fairburn & Agras, 2002). Therefore, our study cannot draw a strong conclusion that decreased AS is the *causal* mechanism accounting for the alleviation in anxiety and depression severity and impairment produced by mindfulness training. Future studies could measure outcomes (anxiety and depression) and the mediator (AS) at different time points so that the temporal component can be considered in the causality analyses of the mechanism. Second, participants in the current study had high psychological distress and were predominantly college-educated. It is not clear whether other populations may experience anxiety and depression alleviation through the reductions in AS. Studies in the future can examine the role of AS among other populations (e.g., people with a diagnosis of anxiety and/or depressive disorders, people with lower education levels).

Future research may also extend the findings of our study by examining the relationship between AS and other empirically tested mechanisms of MBIs. For example, dispositional mindfulness has been found to mediate the effect of MBIs on emotional distress (Baer, Carmody & Hunsinger, 2012; Gao, Curtiss, Liu & Hofmann, 2018). Previous studies also demonstrated the link between dispositional mindfulness and AS (Kraemer *et al.*, 2015; Tanay *et al.*, 2012). It is possible that mindfulness training brings about improvement of dispositional mindfulness, which then leads to reduced AS and eventually alleviates anxiety and depression. Future research in this direction will have significant implications for clarifying the mechanism of MBIs in alleviating anxiety and depression.

In conclusion, this study demonstrates that eight-week mindfulness training could effectively alleviate anxiety and depression severity and impairment and AS in people with high psychological distress. Most importantly, the influence of mindfulness training on anxiety and depression severity and related functional impairment was mediated by improvement of AS, suggesting AS is a potential mechanism of MBIs. The findings of this study may promote the understanding of why MBIs could reduce anxiety and depression and help practitioners to maximize the effect of MBIs on anxiety and depression.

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