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RESEARCH ARTICLE

A 12-week integrative exercise program improves self-reported mindfulness and interoceptive awareness in war veterans with posttraumatic stress symptoms

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Abstract

Objective Innovative approaches to the treatment of war-related posttraumatic stress disorder (PTSD) are needed. We report on secondary psychological outcomes of a randomized controlled trial of integrative exercise (IE) using aerobic and resistance exercise with mindfulness-based principles and yoga. We expected—in parallel to observed improvements in PTSD intensity and quality of life—improvements in mindfulness, interoceptive bodily awareness, and positive states of mind.

Method A total of 47 war veterans with PTSD were randomized to 12-week IE versus waitlist. Changes in mindfulness, interoceptive awareness, and states of mind were assessed by self-report standard measures.

Results Large effect sizes for the intervention were observed on Five-Facet Mindfulness Questionnaire Non-Reactivity (d = .85), Multidimensional Assessment of Interoceptive Awareness Body Listening (d = .80), and Self-Regulation (d = 1.05).

Conclusion In a randomized controlled trial of a 12-week IE program for war veterans with PTSD, we saw significant improvements in mindfulness, interoceptive bodily awareness, and positive states of mind compared to a waitlist.

KEYWORDS
exercise, interoception, mindfulness, PTSD, veterans

Few war veterans returning with posttraumatic stress disorder (PTSD) from Iraq and Afghanistan receive adequate mental health care in the United States (Hoge et al., 2004; Seal et al., 2010). This is due to the perception of stigma and other barriers to traditional mental health care (Hoge et al., 2004). Therefore, novel ways of delivering care are needed (Hoge, 2010). Innovative interventions, such as aerobic exercise (Fetzner & Asmundson, 2015; Manger & Motta, 2005), yoga (Hoge, 2010; Johnston et al., 2015; Macy, Jones, Graham, & Roach, 2015), and mindfulness-based approaches have been introduced in military settings (Crawford et al., 2013; Kearney & Simpson, 2015; Polusny et al., 2015) and have shown some early promise pending confirmation from further trials (Brewer, 2014).

Given the promise of exercise- and mindfulness-based interventions for PTSD, we developed an integrative exercise (IE) program for veterans that combined aerobic and resistance exercise with yoga movements and postures. In addition to these two elements, we also incorporated mindfulness-based principles throughout the program, including breath training, and an emphasis on maintaining a nonjudgmental attitude, acceptance, and suspension of striving for competitive advantage (Kabat-Zinn, 1990). We tested IE in a randomized-controlled pilot study with military veterans with PTSD, the Veterans Group eXercise study (VGX-study; ClinicalTrials.gov identifier NCT01674244). IE was delivered in group classes three times per week over 12 weeks and compared to a waitlist (WL) control.

As separately reported (Goldstein et al.), participants in the IE group gave high ratings for feasibility and acceptability and demonstrated greater improvement in PTSD symptom severity on the Clinician-Administered PTSD Scale (CAPS; Blake et al., 1995) compared with participants assigned to WL (Blake et al., 1995). Improvement in CAPS total scores for the IE condition was primarily due to a reduction in PTSD hyperarousal symptoms on one of the subscales for PTSD symptom clusters, whereas improvements for symptoms of Re-Experiencing and Avoidance/Numbing did not reach statistical significance (Goldstein et al.). Furthermore, we found a moderate, statistically significant effect of IE on improvement of psychological quality of life (QoL), as measured by the World Health Organization Quality of Life (WHOQOL-BREF; World Health Organization [WHO], 1998) scale.

In addition to key outcomes—feasibility, acceptability, PTSD symptom intensity, and quality of life—we were interested in potential mechanisms of action, which comprise the focus of this report. First, we hypothesized that we may find changes in mindfulness because mindfulness principles such as present-moment awareness, beginner's mind, nonjudgmental attitude, and acceptance were key ingredients of IE. One such principle was presented in each session as the focus of the week (Goldstein et al.). Each principle was based on concepts from mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1990), yoga (Cramer, Lauche, Langhorst, & Dobos, 2016), and mindful breathing (Chesney et al., 2016), similar to the themes commonly discussed as attitudinal foundations of the 8-week MBSR program (Kabat-Zinn, 1990).

Thus, we were interested in testing if the overall therapeutic response was associated with gains in mindfulness. Specifically, our a priori hypothesis was that Non-Reactivity to inner experiences, assessed as one of the five facets of the Five-Facet Mindfulness Questionnaire (FFMQ), might increase with this training (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). Non-Reactivity denotes the tendency to allow thoughts and feelings to come and go, without getting caught up in or carried away by them. IE is intended to provide a safe and trustworthy setting, in which one may gradually learn to shift one's focus of attention toward immediate bodily sensations (e.g., muscular effort, joint activity, breathing, heart rate acceleration) and away from evaluative thoughts regarding one's capacities, self-appraisal, and appraisal-based emotions.

This mindfulness training may support decoupling one's habituated reactions to unpleasant experiences and thoughts, for example, rumination, and reduce war training-related hypervigilance. We expected that this in turn may possibly increase the ability to downregulate hyperarousal (IE → increased nonreactivity as element of mindfulness → reduced hyperarousal as element of PTSD). This would be in line with previous reports on veterans with PTSD undergoing MBSR training that found increases in specific aspects of mindfulness, particularly self-reported Non-Reactivity, associated with reduced PTSD symptoms of hyperarousal (Kearney, McDermott, Malte, Martinez, & Simpson, 2012; Stephenson, Simpson, Martinez, & Kearney, 2016).

Second, we sought to determine whether changes in interoceptive bodily awareness were associated with favorable therapeutic response. Interoception, defined as the representation of the body's internal state (Craig, 2003), includes the processing of both afferent stimulus perceptions from inside the body as well as the attention and

emotional appraisal of and inferences about these sensations (Cameron, 2001; Farb et al., 2015). Interoception is a key concept for the understanding of how the mind affects the body and the body affects the mind, and it is increasingly becoming a target for research in psychology, psychiatry, psychosomatic medicine, and philosophy (Craig, 2003, 2008; Khalsa & Lapidus, 2016). Changes in interoceptive bodily awareness have been suggested as a potential mechanism of action for common mindfulness interventions and may be even more important as mechanism of action for approaches that have a stronger somatic exercise focus than the more mind-focused approaches (Farb et al., 2015; Holzel et al., 2011; Mehling et al., 2009), such as mindfulness and other mind–body programs (Mehling et al., 2011).

IE may be better conceptualized as a body–mind approach that aims at training immediate mindful interoceptive awareness, thereby restoring interoception processing, which has been shown in neuroimaging studies to be altered in individuals with PTSD (Lanius, Frewen, Tursich, Jetly, & McKinnon, 2015; Nicholson et al., 2016; Simmons, Strigo, Matthews, Paulus, & Stein, 2009). Training interoceptive bodily awareness, as practiced with IE, intends to shift the perceptive focus away from thinking about body sensations toward immediately feeling body sensations, thus theoretically further reducing rumination and associated arousal (Farb et al., 2015).

Our a priori hypothesis was that Self-Regulation, the ability to regulate psychological distress by non-evaluative attention to body sensations, assessed as one of the subscales of the Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012), might increase with this training and—together with Non-Reactivity—further increase the ability to downregulate hyperarousal, a key aspect of PTSD (IE → mindful focus on bodily sensations as self-control → reduced mental rumination → reduced hyperarousal). This hypothesis was in part based on previous research, in which Self-Regulation has been shown to be the aspect of interoceptive awareness that changed the most with meditative body-focus training in healthy adults (Bornemann, Herbert, Mehling, & Singer, 2014) but has never been assessed in veterans with PTSD.

Self-Regulation is similar to the concept of acceptance. That is, acknowledging one's symptoms and actively coping with these as taught in Acceptance and Commitment Therapy (Thompson, Arnkoff, & Glass, 2011). This may improve health-promoting behavior by overcoming experiential avoidance behavior, a behavioral element in PTSD (Marx & Sloan, 2005). We expected, to a lesser degree, changes in the same direction for the MAIA subscales of Attention Regulation–the ability to sustain and control attention to body sensations–and Emotional Awareness–the awareness of the connection between body sensations and emotional states (Mehling et al., 2012).

Third, we considered that the capacity to maintain or recover a positive perspective or positive states of mind in the face of perceived stress with PTSD-related symptoms maybe another potential mechanism of action. Positive affect has been shown to mediate stress-reducing effects with fitness exercise (Zschucke, Renneberg, Dimeo, Wustenberg, & Strohle, 2015) and reduced perceived stress with yoga (Riley & Park, 2015). Positive states of mind have been shown to be associated with reduced somatic symptoms and improved perceived general health (Adler, Horowitz, Garcia, & Moyer, 1998) Overall impairment of one's ability to enter positive states of mind has been shown to be linked to the experience of stressful life events such as trauma and negative psychological states (Adler et al., 1998). We hypothesized that positive states of mind, in particular, the items for Focused Attention and Restful Repose as assessed by the Positive States of Mind Scales (PSOM; Horowitz, Adler, & Kegeles, 1988), may improve with IE.

We expected that IE may reduce PTSD symptoms by improving health-promoting behavior. Although the sample size of the pilot study ($N = 47$) did not allow us to formally investigate a potential mediation by these psychological or psychosomatic parameters, we report exploratory analyses of how our secondary outcome measures for changes in mindfulness and interoceptive awareness were associated with the primary outcomes. Based on the results for our primary outcomes (Goldstein et al.), we were particularly interested in using the 12-week PTSD hyperarousal symptoms and psychological QoL, which improved with the intervention, as predicted outcomes and restricted the analyses to these primary outcome variables. We a priori hypothesized that improvements in Non-Reactivity for the FFMQ, Self-Regulation for the MAIA, and PSOM might be associated with improved hyperarousal symptoms and psychological QoL.

1 | METHOD

1.1 | Participants

Participating veterans ($N = 47$) were described in detail in our separate report (Goldstein et al.). Briefly, 42 veterans met *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; American Psychiatric Association, 1994) diagnostic criteria for PTSD, and five met criteria for partial PTSD, defined as a criterion A trauma, criterion B symptoms, and either criterion C or D symptoms or history of PTSD diagnosis but without current criterion B symptoms (Schnurr, 2014). The average symptom duration was 18 years ($SD = 14.49$). Of the participants, 21 veterans were randomly assigned to IE and 26 to WL, with baseline characteristics similar between groups. The sample was mostly male (81%) and racial or ethnic minority (60%); age ranged from 24 to 69 years (mean [M] = 46.8); the mean CAPS score at baseline was 61 (standard deviation [SD] = 17.27; scale range: 0–136).

1.2 | Intervention

For the 12 week IE intervention, every 50-minute session began with a welcome, body-mind centering, mindful breathing coordinated with slow movement, and a brief verbal presentation of the mindfulness principle of the week (5 minutes). Thereafter, instructors led participants in a group-based dynamic warm-up (e.g., jumping jacks, fast walking, and running); a series of aerobic (e.g., running, steps, lunges); resistance training exercises with free weights and elastic bands; and doing yoga postures (40 minutes).

After focus group interviews with war veterans, the mindfulness principles of the week, derived from MBSR (Kabat-Zinn, 1990)–Focus, Breathe, Respect, Patience, New Start, Just Be, Acknowledgement, Trust, and Let Go!–were presented in a language adapted to our study population. The week's principle was highlighted at the beginning of each session and repeatedly presented during the exercise class when appropriate (e.g., to pay attention to breathing, to respect one's individual physical limits, which may change from class to class, and not to compare one's fitness to that of other participants). Each class ended with a cool-down, including repetition of the body–mind centering and rest (5 minutes). WL participants were offered to join the classes after completing their final 12-week assessment.

Participants in both groups were assessed at baseline and weeks 4, 8, and 12. Clinical interviewers were blind to group assignment. The study was approved by the Committee on Human Research at the University of California, San Francisco, and the San Francisco Veterans Affairs Medical Center, and all participants provided written informed consent.

1.3 | Measures

1.3.1 | Mindfulness

The 39-item Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006; Baer et al., 2008) assesses the five facets of mindfulness: Observing, Describing, Acting with Awareness, Non-Judging, and Non-Reactivity to Inner Experience. Observing refers to noticing or attending to internal and external experiences such as sensations, cognitions, emotions, sights, sounds, and smells. Describing refers to labeling internal experiences with words. Acting with Awareness refers to attending to one's activities of the moment and can be contrasted with behaving mechanically while attention is focused elsewhere (often called automatic pilot). Non-Judging of inner experience refers to taking a nonevaluative stance toward thoughts and feelings. Non-Reactivity to Inner Experience indicates the tendency to allow thoughts and feelings to come and go without getting caught up in or carried away by them (Baer et al., 2008),

Participants rated the items on a 5-point Likert scale. The FFMQ has been shown to have good internal consistency (alpha coefficients range from .72 to .92) in diverse samples and significant correlations in the predicted directions with other psychological parameters (Baer et al., 2008). The FFMQ has been shown to be sensitive to change (Baer, 2009) and therefore can be used as a correlate of treatment response. Cronbach's alphas in our sample are reported in Table 2.

1.3.2 | Interoceptive bodily awareness

The MAIA (Mehling et al., 2012) is a self-report measure recently developed to capture changes in interoception associated with mind–body interventions. The MAIA is a 32-item instrument comprising eight subscales: Noticing, Not-Distracting, Not-Worrying, Attention Regulation, Emotional Awareness, Self-Regulation, Body Listening, and Trusting. Participants rated the items on a 6-point Likert scale, with higher scores indication higher interoceptive awareness. The MAIA assesses regulatory aspects of interoceptive processing and is able to differentiate between clinically relevant attention styles toward bodily symptoms: anxiety and hypervigilance-driven versus acceptance and mindfulness-based attention (Bornemann et al., 2014; Mehling, 2016). It has been validated in numerous languages and shown to have adequate psychometric properties including sensitivity to change (see https://www.osher.ucsf.edu/maia/; Mehling et al., 2013).

1.3.3 | Positive states of mind

The PSOM (Horowitz et al., 1988) assesses the capacity for positive states of mind: focused attention, productivity, responsible caretaking, restful repose, sharing, sensuous nonsexual pleasure, and sensuous sexual pleasure. Participants rated the items on a 4-point Likert scale ranging from 0 (*unable to have it*) to 3 (*have it easy*). A reduced capacity of experiencing positive states of mind, associated with situations of chronic stress, has been shown to be associated with somatic symptoms, a risk factor for health (Horowitz et al., 1988). It was found to be internally consistent and sensitive to degrees of life stress.

1.3.4 | PTSD symptoms

The CAPS (Blake et al., 1995) was used to assess PTSD symptom frequency and intensity pre- and posttreatment via semistructured interview for *DSM-IV*. Total scores may range from 0 to 136, with higher scores indicating higher symptom severity. Criterion symptom clusters (re-experiencing, avoidance/numbing, hyperarousal) were evaluated separately. The CAPS has good test-retest reliability and internal consistency, and because of its length and participant burden, was assessed only at baseline and 12 weeks (Blake et al., 1995).

1.3.5 | Quality of life

WHOQOL-BREF (WHO, 1998). This 26-item self-report assesses QoL in several domains; physical health and psychological health were included in this study. Domain scores range from 4 to 20, with higher scores indicating greater health in each domain. The WHOQOL-BREF has good reliability and validity (Forbes et al., 2012). In our sample, Cronbach's alpha was 0.82 for the entire scale and 0.88 for the psychological health subscale.

1.4 | Analyses

Linear mixed-effects models were used to evaluate changes in mindfulness, interoceptive awareness, and positive state of mind using all available data (intention-to-treat), with the group (IE vs. WL), time point, and group-by-time interaction entered as fixed effects and subjects entered as random effects. Cohen's *d* effect sizes were calculated as the group difference in baseline-adjusted posttreatment scores divided by the standard deviation of baseline scores. Completers were defined as participants with data collected at baseline and 12 weeks because we assessed CAPS as main outcome data only at these time points. Because this is a small pilot study, we emphasized effect sizes, rather than *p*-values, and did not adjust for multiple comparisons. Missing values were not replaced.

We explored whether changes in secondary outcome psychological variables mediated changes in primary outcomes—CAPS scores and Psychological WHOQOL—using path analyses models (see Figure 1) implemented in Stata14 (Stata14, 2015). Bootstrapped standard errors were used to test the significance of the mediation effects. We analyzed only 12-week scores controlled for baseline scores for those potentially mediating variables that in the above-mentioned analysis had shown significant between-group differences for changes.

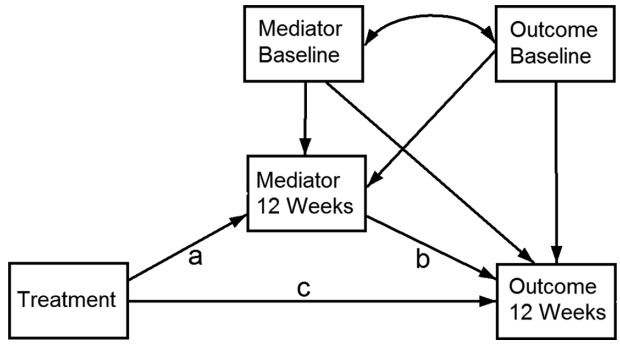

FIGURE 1 Generic model for the exploratory mediation analysis
Note. direct effect = c; indirect effect = a times b; total effect = direct effect + indirect effect = (a times b) + c.

TABLE 1 Baseline scores (± standard deviation) for FFMQ, MAIA, and PSOM [scale range] in both groups: IE or WL

	IE ($n = 21$)	WL ($n = 26$)
FFMQ Observe [1–5]	3.2 (±0.7)	3.4 (±0.8)
Describing	2.8 (±0.6)	3.0 (±0.9)
Acting with Awareness	2.9 (±0.8)	3.1 (±0.9)
Non-Judging Inner Experience	2.9(±0.9)	3.0 (±0.9)
Non-Reactivity Inner Experience	2.8 (±0.6)	2.8 (±0.7)
MAIA Noticing [0–5]	3.1 (±1.1)	2.9 (±1.1)
Not-Distracting	1.6 (±1.1)	2.2 (±1.1)
Not-Worrying	3.0 (±1.1)	2.8 (±0.8)
Attention Regulation	2.7 (±1.2)	2.4 (±1.2)
Emotional Awareness	3.4 (±1.1)	3.3 (±1.2)
Self-Regulation	2.3 (±1.2)	2.5 (±1.4)
Body Listening	2.0 (±1.4)	2.0 (±1.4)
Trust	3.1 (±1.4)	2.8 (±1.4)
PSOM total [0–18]	10.4 (±3.2)	10.3 (±3.4)
Focused Attention [0–3]	1.7 (±0.8)	1.6 (±0.7)
Restful Repose [0–3]	1.4 (±0.6)	1.6 (±0.7)

Note. IE = integrative exercise; WL = waitlist; FFMQ = Five Facet Mindfulness Questionnaire; MAIA = Multidimensional Assessment of Interoceptive Awareness; PSOM = Positive States of Mind Scales.

2 | RESULTS

2.1 | Baseline data

Baseline scores for mindfulness and interoceptive awareness were similar between groups with one exception: WL participants seemed to distract themselves less from symptoms of pain and discomfort than IE participants (MAIA Not-Distracting subscale; see Table 1).

2.2 | Changes in secondary outcomes

Following Cohen's suggestions, we consider effect sizes of > .80 as large and found such effect sizes for the intervention on scores of FFMQ Non-Reactivity (.85) and the MAIA subscales for Body Listening (.80) and Self-Regulation (1.05; see Table 2). Moderate effect sizes (above .50) were found for FFMQ subscales for Observing (.76), the MAIA subscale for

TABLE 2 Baseline-adjusted standardized between-group effect sizes for pre-post changes in psychological scales

	Scores at 12 weeks		Change Score				
	IE	WL	IE	WL	α	p^*	ES*
FFMQ **Observing** [1 – 5]	3.4	3.1	0.24	−0.31	0.86	.002	**0.76**
Describing	3.4	3.1	0.39	0.09	0.91	.069	0.46
Acting Awareness	3.1	3.2	0.11	0.22	0.93	.691	−0.09
Non-Judging	3.2	3.3	0.34	0.35	0.93	.975	−0.01
Non-Reactivity	3.1	2.8	0.41	−0.09	0.80	.001	**0.85**
MAIA Noticing [0 – 5]	3.4	3.0	0.36	−0.01	0.84	.250	0.41
Not-Distracting	1.9	2.6	0.45	0.48	0.72	.557	0.20
Not-Worrying	3.0	2.8	−0.08	0.05	0.42	.958	−0.01
Attention Regulation	2.8	2.1	0.14	−0.24	0.93	.068	0.47
Emotional Awareness	3.7	2.8	0.14	−0.49	0.88	.024	**0.71**
Self-Regulation	3.2	2.1	1.11	−0.23	0.88	.000	**1.05**
Body Listening	2.7	2.0	0.93	−0.08	0.87	.002	**0.80**
Trusting	3.3	2.9	0.38	0.19	0.94	.266	0.25
PSOM total	12.8	10.6	2.5	0.6	0.86	.025	**0.54**
Focused Attention	2.2	1.7	0.5	0.0	–	.052	**0.54**
Restful Repose	1.9	1.5	0.1	−0.5	–	.056	**0.65**

Note. ES = effect size; IE = integrative exercise; WL = waitlist; FFMQ = Five Facet Mindfulness Questionnaire; MAIA = Multidimensional Assessment of Interoceptive Awareness; PSOM = Positive States of Mind Scales.
Effect sizes > .50 are in boldface. α = Cronbach's alpha in our sample. * = p values and ES by mixed-effects models (intention-to-treat); 12-week and change scores are from completers only.

TABLE 3 Coefficients for direct and indirect effects of group [95% confidence intervals] for key psychological variables on total CAPS outcome changes from baseline to 12 weeks

Mediating variable	Total Group Effect	Direct Group Effect	Indirect Group Effect
FFMQ Observe	−14.5 [−27.9, −1.2]	−13.0 [−27.3, 1.3]	−1.5 [−8.6, 5.6]
FFMQ Non-Reactive	−16.3 [−29.8, −2.8]	−12.2 [−29.0, 4.6]	−4.1 [−12.6, 4.3]
MAIA Emotional Awareness	−13.5 [−27.8, 0.8]	−9.2 [−24.6, 6.2]	−4.3 [−9.7, 1.1]
MAIA Self-Regulation	−14.9 [−29.4, −0.5]	−18.5 [−37.6, 0.6]	3.5 [−5.9, 13.0]
MAIA Body Listening	−15.0 [−29.9, −0.2]	−17.1 [−35.2, 1.1]	2.0 [−4.7, 8.7]
PSOM	−13.1 [−25.4, −0.9]	−7.0 [−20.7, 6.7]	−6.1 [−13.5, 1.3]

Note. CAPS = Clinician-Administered PTSD Scale; FFMQ = Five Facet Mindfulness Questionnaire; MAIA = Multidimensional Assessment of Interoceptive Awareness; PSOM = Positive States of Mind Scales.

Emotional Awareness (.71), and the PSOM subscale (.54), as well as the two items that we were particularly interested in, namely, Focused Attention (.54) and Restful Repose (.65) as specific positive states of mind.

2.3 | Exploratory mediation analyses

Tables 3–5 show the results of our exploratory mediation analyses. Based on confidence intervals, the majority of indirect effects in these models did not reach statistical significance in our relatively small study sample (see Tables 3–5). However, there were two exceptions showing significant indirect effects: In the model for group effects on CAPS hyperarousal subscale changes, the indirect effect for PSOM was significant (see Table 4); and in the model for group effects on Psychological QoL (WHOQOL-D2) score changes, Non-Reactivity (FFMQ) was a significant indirect mediator (see Table 5).

TABLE 4 Coefficients for direct and indirect effects of group [95% confidence intervals] for key psychological variables on hyperarousal (CAPS-D) outcome changes from baseline to 12 weeks

Mediating Variable	Total Group Effect	Direct Group Effect	Indirect Group Effect
FFMQ Observe	−4.7 [−9.6, 0.2]	−3.1 [−8.3, 2.1]	−1.6 [−4.3, 1.0]
FFMQ Non−Reactive	−5.4 [−10.2, −0.5]	−3.2 [−8.2, 1.8]	−2.2 [−5.1, 0.7]
MAIA Emotional Awareness	−4.6 [−9.8, 0.6]	−2.7 [−8.1, 2.6]	−1.9 [−4.2, 0.4]
MAIA Self-Regulation	−4.8 [−9.9, 0.3]	−6.1 [−13.5, 1.3]	−1.3 [−2.9, 5.5]
MAIA Body Listening	−4.7 [−9.8, 0.3]	−4.4 [−11.0, 2.3]	−0.4 [−3.1, 2.4]
PSOM	−4.6 [−9.4, 0.3]	−1.5 [−6.2, 3.3]	−3.1 [−6.1, −0.1]

Note. CAPS = Clinician-Administered PTSD Scale; FFMQ = Five Facet Mindfulness Questionnaire; MAIA = Multidimensional Assessment of Interoceptive Awareness; PSOM = Positive States of Mind Scales.

TABLE 5 Coefficients for direct and indirect effects of group [95% confidence intervals] for key psychological variables on psychological quality of life (WHOQOL-D) outcome changes from baseline to 12 weeks

Mediating Variable	Total Group Effect	Direct Group Effect	Indirect Group Effect
FFMQ Observe	.89 [− .07, 1.86]	.51 [− .44, 1.46]	.38 [− .05, 0.82]
FFMQ Non − Reactive	.96 [− 0.12, 2.05]	.34 [− 0.59, 1.27]	.62 [0.03, 1.22]
MAIA Emotional Awareness	.63 [− 0.28, 1.55]	.68 [− 0.25, 1.62]	−.05 [−0.57, 0.47]
MAIA Self-Regulation	.79 [− 0.20, 1.78]	.81 [− 0.22, 1.85]	−.02 [−0.66, 0.62]
MAIA Body Listening	.80 [− 0.19, 1.78]	.70 [− 0.33, 1.73]	.09 [− 0.28, 0.47]
PSOM	.68 [− 0.32, 1.67]	.35 [− 0.68, 1.38]	.32 [− 0.20, 0.84]

Note. WHOQOL-BREF = World Health Organization Quality of Life; FFMQ = Five Facet Mindfulness Questionnaire; MAIA = Multidimensional Assessment of Interoceptive Awareness; PSOM = Positive States of Mind Scales.

3 | DISCUSSION

We have separately reported (Goldstein et al.) that a randomized controlled trial (RCT) of a 12-week IE program for treating war veterans with PTSD showed promising results for reducing PTSD symptom intensity (assessed by CAPS) and increasing psychological QoL (by WHOQOL). The average reduction of 31 points observed on the total CAPS score—a clinically significant reduction in PTSD symptom severity—met or exceeded the results of empirically supported psychotherapies (i.e., cognitive processing therapy or prolonged exposure therapy) reported from other trials of veterans with PTSD (Forbes et al., 2012; Tuerk et al., 2011). Here, we report on secondary outcome data from this pilot RCT comparing IE with a WL control. We found that IE is associated with significant improvement in facets of mindfulness, in several aspects of interoceptive awareness and in positive states of mind (PSOM) among war veterans.

As hypothesized, Non-Reactivity for the FFMQ and Self-Regulation for the MAIA increased for the IE group, compared to WL. Non-Reactivity showed the largest positive effect size in the FFMQ and Self-Regulation the strongest on the MAIA in parallel with the reduction in Hyperarousal on the CAPS. The intervention investigated here integrates physical fitness training with breath training and attitudinal principles of mindfulness drawn from the MBSR program (Kabat-Zinn, 1990), yoga postures and movements. This mind–body training emphasizes nonevaluative, immediate awareness of body sensations and breathing (Mehling et al., 2011). IE modifies primarily mechanical and achievement-oriented physical fitness exercises by imbuing them with elements for "mental fitness" such as coordination of movements with breathing and guided mental attention. As mentioned above, Non-Reactivity to inner experience denotes the tendency to allow thoughts and feelings to come and go, without getting caught up in or carried away by them. Self-Regulation assesses the ability to regulate psychological distress by attention to body sensations.

Mindfulness training is thought to increase focused attention. This was confirmed by a moderate improvement in the respective PSOM Focused Attention subscale, viewed as a positive state of mind that goes along with the capacity for Restful Repose. Improvements in positive states of mind are in line with previous studies that describe increases

in positive affect with mindfulness training (Garland, Geschwind, Peeters, & Wichers, 2015) and with physical exercise (Dua & Hargreaves, 1992).

In addition, we saw moderate to large effect sizes for improved scores on the FFMQ Observe subscale and the MAIA subscales for Emotional Awareness and Body Listening. FFMQ Observe indicates the disposition to notice or attend to both internal and external experiences and does not distinguish between interoception and exteroception. While external experience refers to sights, sounds, and smells, internal experience refers to sensations, cognitions, and emotions. According to the James-Lange theory and somatic marker hypothesis (Damasio & Carvalho, 2013), emotions have been understood more recently by neuroscientists (Barrett & Satpute, 2017) as being based on the central processing of interoceptive sensations and feelings. This is captured by the MAIA subscale for Emotional Awareness, the tendency to be aware of the connection between body sensations and emotional states. If one's behavioral reactivity to emotions can be slowed down (increase in FFMQ Non-Reactivity), then a refined awareness of these emotions coupled with mindful nonreactivity may reduce hyperarousal and one's capacity to "listen" to emotion-related signals for insight and decision making (Lamm & Singer, 2010; Mirams, Poliakoff, Brown, & Lloyd, 2013), indicated by increases in the MAIA Body Listening subscale. MAIA Self-Regulation stood out as the largest positive standardized effect size, which is in line with results from a study of a 6-month Presence training using a body scan and mindful attention to breathing in healthy volunteers (Bornemann et al., 2014).

It would be interesting to test the hypothesis that an increase in intervention-related Non-Reactivity, Self-Regulation, and Positive States of Mind may mediate the improvement in primary study outcomes, PTSD symptom intensity and QoL. Although the sample size of this pilot study was insufficient to conduct rigorous tests of mediation effects, our exploratory results suggest that PSOM and FFMQ Non-Reactivity may partially mediate the treatment effect on primary outcomes (CAPS Hyperarousal subscale, Psychological WHOQOL), suggesting that the role of these mindfulness-related constructs in mediating PTSD treatment outcomes is a promising direction for future research.

3.1 | Limitations

We report data from a small pilot study. First, our sample size severely limits the power of our analyses, and *p*-values are of questionable validity, in particular when used in multiple comparisons. We decided to focus our report on the more meaningful standardized effect sizes. Numerous results, however, were statistically significant with *p*-values below 0.05, despite the small sample size. Second, the small sample size precluded more rigorous mediation analyses. Third, the WL control group does not control for time spent in group activities together. Finally, one of the eight MAIA subscales with only three items showed a poor scale reliability index, which had no influence on our main results.

4 | CONCLUSION

In a RCT of a 12-week IE program for war veterans with PTSD, we saw significant improvements in mindfulness, interoceptive bodily awareness, and positive states of mind compared to a WL control. These changes in secondary outcomes may be partial mechanisms of action for how IE creates the observed improvements in PTSD symptoms and QoL, but a larger study is needed to determine whether they formally mediate these gains.

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