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Research Paper

Yoga for PTSD and the role of interoceptive awareness: A preliminary mixed-methods case series study

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ABSTRACT

Introduction. – A growing body of literature suggests yoga is a promising adjunct or standalone treatment for Posttraumatic Stress Disorder (PTSD). The mechanism behind these improvements in physical and mental health outcomes is less understood. Interoceptive awareness, the ability to perceive internal bodily sensations, is proposed to be a crucial factor behind yoga, yet research investigating interoception in PTSD is limited.
Objective. – This study extends current research by investigating the role of interoceptive awareness, and improved mental health outcomes, using a self-report measure of interoceptive awareness at baseline, during, and post a Trauma Sensitive Yoga intervention, in addition to qualitative interviews.
Method. – The outcomes of an eight-week Trauma Sensitive Yoga intervention for people with PTSD (n = 3) were examined using a case series design.
Results. – Overall, the results indicate participants experienced significant increases in interoceptive awareness and significant decreases in PTSD symptoms, depression, anxiety, and stress.
Conclusion. – These preliminary findings suggests that increased interoceptive awareness may be a mechanism producing the beneficial outcomes of yoga for those affected by trauma. The implications of these findings for the effectiveness and development of PTSD treatment, as well as the use of yoga treatment, is discussed.

1. Introduction

Posttraumatic Stress Disorder (PTSD) can develop after exposure to a traumatic event/s and significantly impairs everyday functioning and quality of life (American Psychiatric Association, 2013). Evidence based therapies, such as Cognitive Behavioural Therapy and Eye Movement Desensitization and Reprocessing, have shown beneficial effects in reducing PTSD symptoms (e.g. Bradley et al., 2005; Foa et al., 1995; Van der Kolk et al., 2007), and are recommended in the Australian National Health and Medical Research Council guidelines as having the most robust body of evidence that can be trusted to guide practice (National Health and Medical Research Council, 2013). Prolonged Exposure Therapy has been extensively researched and can be viewed as the most efficacious treatment to date, linked to significantly greater reductions in PTSD symptoms from pre-post treatment compared to treatment as usual (Nacasch et al., 2011), supportive counselling (Schnurr et al., 2007), and waitlist control (Foa et al., 2005).

These existing therapies, however, have limitations including high dropout rates, worsening of symptoms, and residual symptoms post treatment. In response well-controlled trials of novel and developing interventions for PTSD or adjunctive treatments have been proposed to address some of these difficulties with treatment (National Health and Medical Research Council, 2013).

A growing body of research has investigated yoga interventions for the treatment of trauma populations with preliminary, yet promising results. Much of the research includes studies with small sample sizes, both randomised and non-randomised, as well as larger non-randomised studies. Following yoga interventions lasting 6 weeks and up to 6 months, reductions in PTSD symptoms have been shown for a number of populations, including war veterans (Carter et al., 2013; Johnston et al., 2015; Staples et al., 2013; Mccarthy et al., 2017)., tsunami survivors (Descilo et al., 2010), and those with current full or subthreshold PTSD symptoms (Mitchell et al., 2014). However, a recent systematic review and

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meta-analysis (Cramer et al., 2018) reports low quality evidence and high dropout rates in yoga studies.

Using more rigorous methods, two studies used randomized controlled methods with larger sample sizes. Following an 8 session Kundalini yoga intervention, participants with PTSD experienced significantly greater improvements on measures of PTSD, sleep, positive and negative affect, anxiety, stress, and resilience, compared to a waitlist control (n = 80, 30% dropout; Jindani et al., 2015). Additionally, Van der Kolk et al (2014) investigated a 10-week Trauma Sensitive Yoga (TSY) intervention for 64 women experiencing chronic PTSD compared to supportive women's health education. From pre to post treatment, the yoga group had significantly greater reductions in PTSD symptoms compared to the control.

To explore the mechanisms behind these yoga interventions qualitative studies have been conducted. Following the research by Van der Kolk et al (2014), two qualitative studies investigated participant's experiences of the yoga in the randomised control trial (Rhodes, 2015; West et al., 2017). Via interviews, Rhodes (n = 39; 2015) found the women reported increased ownership, control, and connection to their bodies, emotions, and thoughts after the yoga. Key themes identified included greater interoceptive awareness, emotion regulation abilities, self-care capacities, connection with others, and sense of control and hope over their lives, compared to before the yoga intervention. Similarly, West, Liang, and Spinazzola (n = 31; West et al., 2017) identified main themes from interviews, including increased gratitude and compassion, relatedness, acceptance, centeredness, and empowerment compared from pre- to post-yoga.

Improvements in interoceptive capabilities have been proposed as crucial in the effectiveness of yoga in treating those with trauma (Caplan et al., 2013; Van der Kolk et al., 2014; Emerson, 2015). Interoceptive awareness can be understood in a number of ways, for the purpose of this paper interoceptive awareness refers to the ability to perceive internal physiological sensations of the body, including heart beat, hunger, and autonomic nervous system sensations related to emotions (Mehling et al., 2012), and is compromised subsequent to a traumatic event. Neuroimaging studies of trauma demonstrate decreased activation in the prefrontal cortex, and brain areas related to interoceptive awareness (Herringa et al., 2012; Van der Kolk, 1994). Following trauma, survivors commonly experience a sense of disconnection between their mind and body (Herman, 2015; Van der Kolk et al., 2014). Most trauma involves physical violation of the body, and individuals exposed to trauma can develop fear of their own emotions and bodily sensations. Those with PTSD can fluctuate between intrusive reliving of trauma symptoms in their bodies and minds, and avoidance of bodily sensations or thoughts (Herman, 2015). Engagement in yoga may increase interoceptive abilities such as increased awareness, recognition, and acceptance of internal sensations and emotional reactions, and in turn improve the ability to regulate affect and impulsive behaviours.

A randomised controlled trial of integrative exercise (IE) with yoga postures compared to a waitlist control for military veterans with PTSD investigate changes in interoceptive awareness (n = 47; Mehling et al., 2017). Following three IE classes per week for 12 weeks, those in the IE group showed an increases in (with large effect sizes) on two interoceptive awareness scales: body listening the ability to use emotion-related signals from the body for insight and decision making. And self-regulation, the capacity to regulate psychological distress via non-judgmental attention to body sensations. These changes in interocpetive awareness were hypothesised to be a mechanism behind reductions in PTSD symptoms and increases in quality of life associated with the intervention.

Although increased interoceptive awareness is proposed as a core mechanism of yoga in reducing trauma symptoms, current research on interoceptive awareness is limited. This research, therefore, aims to address the gap in the literature and further explore yoga's impact on interoceptive awareness for people with trauma symptoms. A mixed-methods design was utilised with repeated measurement of interoceptive awareness (body awareness, attention regulation, and emotion regulation) during a TSY intervention for a trauma population. In addition, this study assessed changes in depression, anxiety, stress, PTSD symptoms, and participants subjective experience of the effects of TSY.

Three hypotheses were proposed regarding pre to post, and pre to follow-up, yoga intervention effects. First, it was hypothesised there would be a significant increase in interoceptive awareness on all three subscales. Second, it was hypothesised there would be a significant decrease in PTSD symptoms. Third, it was hypothesised there would be a significant decrease in anxiety, depression, and stress.

2. Method

2.1. Participants

Participants aged 18 and above were recruited via flyers distributed to organisations related to mental health. A brief screening call was conducted to rule out exclusion criteria, screen for symptoms of PTSD based on DSM5 criteria (American Psychiatric Association, 2013), complete the Adverse Childhood Experiences Questionnaire (ACE; Felitti et al., 1998), and answer demographic information. The exclusion criteria included those breastfeeding or pregnant, unstable medical conditions, significant suicidal or self-harm risk, and substance abuse or dependence in the last 6 months. Participants were required to continue with treatment as usual, both psychological and pharmacological. PTSD was established based on the Clinician Administered PTSD Scale (CAPS) 5 diagnosis of criteria met for A-G (Weathers et al., 2013).

A total of six participants commenced the study, all of whom were attending the Birchtree Centre of Excellence- Trauma, Addictions, and Eating Disorder for trauma therapy. Three participants (4, 5 and 6) discontinued the study and exit interviews were conducted (see in Table 1). Participant 4 discontinued due to unavailability for the yoga sessions with attendance to emergency family commitments. Participant 5 discontinued due to unavailability during the yoga sessions with work commitments. Participant 6 discontinued due to finding the travel distance too far and time consuming. Participants were considered to have dropped out and thereby their data excluded from analysis based upon: non-completion of 3 or more yoga sessions, and non-completion of the post intervention interview and measures. Three participants engaged in the study to the completion (participants 1, 2, and 3) and their data was included for analysis. Baseline demographic details of participants who completed and discontinued the study are depicted in Table 2 for comparison purposes. For self-report measure baseline data, the baseline for each individual was calculated by taking the average of their scores from the three time points assessed pretreatment. Participants 1, 3, 4, 5, and 6 reported a history of formal yoga experience, participant 2 reported a history of informal yoga experience.

Participant 1 was a 23-year-old female who reported a history of 9 directly experienced traumatic life events, and 5 categories of adverse childhood experiences. She identified sexual and physical assault from multiple attackers as her index trauma. Participant 2 was a 27-year-old female who reported a history of 4 directly experienced traumatic life events, and 4 categories of adverse childhood experiences. She identified emotional abuse as her index trauma. Participant 3 was a 25-year-old female who reported a history of 3 directly experienced traumatic life events, and

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Table 1
Attendance of yoga sessions and reasons for non-attendance/discontinuation.

Participant	TSY1	TSY2	TSY3	TSY4	TSY5	TSY6	TSY7	TSY8	Reason for non-attendance/discontinuation
P1	√	√	√	√	x	√	√	√	TSY5 = unwell
P2	√	√	x	√	√	√	√	√	TSY3 = unwell
P3	√	√	√	√	√	x	x	x	TSY6 = unwell. TSY7-8 = emergency family commitments
P4	√	√	√	√	√	x[a]	–	–	Discontinuation due to emergency family commitments
P5	√	√	x	√	√	√	x[a]	–	TSY3 = forgot. Discontinuation due to work commitments
P6	√	x[a]	–	–	–	–	–	–	Discontinuation due to travel distance/other therapy commitments

TSY: trauma sensitive yoga; P: participant; √: attended; x: did not attend.
[a] Discontinued.

2 categories of adverse childhood experiences. She identified sexual assault as her index trauma.

2.2 Design/procedure

This study employed mixed-methods, and utilised both quantitative and qualitative measures. A replicated single-case AB design (Byiers et al., 2012) with follow-up was used across 6 subjects, 3 of whom completed the study. Three participants are the minimum number of cases required for a case series (Barlow et al., 2009). A repeated measures baseline (A) with 3 time points across a 6 week period was obtained for each participant prior to the intervention. Following this, repeated measures were obtained every second week (2, 4, 6, and 8) of the 8 week TSY intervention (B). Post measures and qualitative interviews were obtained within two weeks post intervention and follow-up measures two months post-intervention. Measures used for the baseline, intervention time points, post, and follow-up included the National Stressful Events Survey for Posttraumatic Stress Disorder (PTSD)-Short Scale (NSESSS; Kilpatrick et al., 2013, Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012), and Depression Anxiety Stress Scale, 21 items (DASS-21; Lovibond & Lovibond, 1995). The Clinician Administered PTSD Scale (CAPS-5; Weathers et al., 2013) was administered at the baseline time point 1 and two weeks post the intervention. The study was approved by University of Technology Sydney Human Research Ethics, REF NO.2015000482-44, informed consent was obtained for all participants.

2.2. Treatment

2.2.1. Trauma sensitive yoga (TSY) intervention/setting

Eight consecutive weeks of a one-hour once weekly Trauma Sensitive Yoga (TSY) class, Tuesday at 10 am at the Birchtree Centre of Excellence- Trauma, Addictions, and Eating Disorders. The instructor was fully accredited in Trauma Sensitive Yoga program as developed by the Trauma Center at the Justice Resource Institute in Brookline, Massachusetts and outlined by Emerson (2015).

2.3. Measures

2.3.1. Clinician administered PTSD scale (CAPS-5; Weathers et al., 2013)

CAPS-5 was administered by the first author, who was a provisionally registered psychologist. CAPS-5 is a valid and reliable measure (Mueser et al., 2001). Higher scores equals greater PTSD symptoms.

2.3.2. The life event checklist-5 (LEC-5; Weathers et al., 2013)

The LEC-5 has strong concurrent validity with other established measures of PTSD symptoms (Gray et al., 2004).

2.3.3. Adverse childhood experiences questionnaire (ACE; Felitti et al., 1998)

The measure is both reliable and valid (α = 0.81; Bruskas and Tessin, 2013). Higher scores equals greater number of adverse childhood events experienced.

2.3.4. The national stressful events survey for posttraumatic stress disorder (PTSD)-Short Scale (NSESSS; Kilpatrick et al., 2013)

This measure is both reliable and valid (α = .93; Miller-Graff et al., 2015). Higher scores equals greater PTSD symptoms.

2.3.5. Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012)

MAIA is a 32 item self-report measure of interoceptive awareness with 8 subscales. Higher scores equals greater interoceptive awareness.

Table 2
Baseline demographic variables of study participants.

Variable	Participants who completed the study (n = 3)	Participants who discontinued the study (n = 3)
Age, mean (SD)	25.00 (2.00)	51.67 (2.10)
Gender	m: 0, f: 3	m: 1, f: 2
Employed, number of persons	2	2
University graduate, number of persons	1	2
Trauma symptom measures		
CAPS total score, 1 month, mean (SD)	48.33 (11.85)	48.00 (2.00)
NSESSS, mean (SD)	21.33 (11.89)	23.56 (3.83)
DASS-21		
Depression, mean (SD)	24.89 (6.05)	26.67 (13.61)
Anxiety, mean (SD)	19.78 (3.29)	25.56 (7.19)
Stress, mean (SD)	27.78 (4.07)	32.22 (8.15)
MAIA (score range 0–5)		
Attention regulation, mean (SD)	1.87 (0.60)	2.24 (1.04)
Self-regulation, mean (SD)	2.56 (0.61)	1.72 (1.09)
Body Listening, mean (SD)	2.30 (0.93)	2.26 (1.06)

SD: standard deviation.

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The eight scales are demonstrated to have adequate to excellent internal consistency reliabilities (ranging from α = 0.66 to 0.87) (Mehling et al., 2012). In addition, MAIA is shown to have sensitivity to change (Bornemann et al., 2015; de Jong et al., 2016). The current study design required repeated assessment, therefore three subscales were selected to reduce participant burden: body listening, attention regulation, and self-regulation. These scales were considered the best to measure interoceptive awareness. They have been shown to have the highest effect sizes of the eight subscales in previous research on mindfulness and integrated exercise with yoga (Bornemann et al., 2015; Mehling et al., 2017). Body Listening refers to the ability to actively listen to the body for insight (e.g. ''When I am upset, I take time to explore how my body feels''), attention regulation is the ability to sustain and control attention to body sensations (e.g. ''I can return awareness to my body if I am distracted''), Self-Regulation refers to the ability to regulate distress by attention to body sensations (e.g. ''I can use my breath to reduce tension'').

2.3.6. Depression anxiety stress scale, 21 items (DASS-21; Lovibond & Lovibond, 1995)

The internal consistency and concurrent validity of the DASS and DASS-21 are demonstrated to be in the acceptable to excellent ranges (Antony et al., 1998). Higher scores equals greater depression, anxiety, or stress symptoms.

2.3.7. Post-intervention interview

Qualitative interviews were conducted following TSY classes based on the Semi-Structured Interview schedule taken from Kinser et al. (2013). This included open-ended questions on participants' overall impressions about: The intervention itself, aspects of the intervention that were or were not beneficial, what made participation in the intervention difficult or easy, and individuals' plans for future use of yoga or other methods for mood regulation.

3. Data analysis

Data analysis included visual inspection (Wolery et al., 2011), Reliable Change Index (RCI) and test of clinical significance (Jacobson & Truax, 1991), and qualitative analysis using Thematic Analysis method (Braun and Clarke, 2006). The formula for the RCI is presented below, the standard error calculation was based on the methods by Jacobson & Truax (1991): RCI = $\left(??^2 - ??^1\right)/\sqrt{2}??^2\mathrm{E}$, where$??\mathrm{E}, = ???\sqrt{1-\alpha}$

Standard deviations were calculated using data from the six participants who commenced the study to provide greater estimation to the population. Coefficient alphas (Cronbach method) for each measurement was obtained from prior research (DASS-21: Brown et al., 1997; MAIA: Brown et al., 2017; NSESSS: Le Beau et al., 2014; CAPS-5: Hunt et al., 2017). An RCI greater than +1.96 is considered significant at the $P < .05$ level.

For the Clinical Cutoff Score, means and standard deviations for the current clinical population were calculated using data from the six participants who commenced the study. Means and the standard deviations from normative non-clinical populations were obtained from previous research (DASS-21: Crawford et al., 2011; MAIA: Mehling et al., 2012; NSESSS: LeBeau et al., 2014; CAPS-5: Hunt et al., 2017). The CAPS-5 is a recent measure and to our knowledge does not have a recommended clinical cut-off Score, a non-clinical population was therefore selected based on the recommended cut-off Score of 15 from the CAPS (DSM-4) which is closely related to the CAPS-5 (Griffin et al., 2004).

4. Results

4.1. Visual inspection

Figs. 1 and 2 show participant's ratings for negative affect (DASS-21), interoceptive awareness (MAIA), and PTSD symptoms (NSESSS), during baseline (time points 1, 2 and 3), across the course of the yoga intervention (every second week: time points 4, 5, 6 and 7), one-week post intervention (time point 8), and two months' follow-up (time point 9). Participant 3 has missing data at time point 7, graphs were drawn to show continued trend from time point 6 to 8.

4.2 Reliable change and clinical significance

Table 3 shows reliable change and clinical significance calculations for each individual on all measures (DASS-21, MAIA, NSESSS, CAPS-5). Calculations were made for changes pre to post, as well as pre to follow-up.

The results show participants one and two experienced reliable and clinically significant increases on all interoceptive awareness subscales pre-post and pre-follow-up yoga. Participant three showed a clinically significant and reliable decrease in Body Listening pre-post-yoga. For depression, all participants showed clinically significant and reliable decreases pre-post-yoga, this was maintained for participant two at follow-up. For anxiety, participant two and three showed reliable and clinically significant decreases pre-post-yoga, this was maintained for participant two at follow-up. For stress, all three participants showed a reliable decrease pre-post and pre-follow-up, this was clinically significant for participants two and three pre-post-yoga, and participants one and two at follow-up. For PTSD symptoms, participants one and two showed reliable and clinically significant decreases on the NSESSS pre-post-yoga, this was maintained for participant two at follow-up, no clinically significant changes on the CAPS-5 pre-post-yoga. Participant three showed reliable and clinically significant increase on the NSESSS pre-follow-up yoga and reliable and clinically significant decrease on the CAPS-5 pre-post-yoga.

4.2. Qualitative analysis

Three core interrelated themes were identified that demonstrate the effects of the Trauma Sensitive Yoga on participants physical and mental health. These themes are outlined below.

4.2.1. Increased interoceptive awareness

Participants discussed increased awareness of present moment internal experiences, including bodily sensations and mental processes. They described both challenges and benefits. Challenges identified were increased awareness of an active mind as a result of the slow nature of the practice, and therefore difficulties controlling their attention to find a state of calm. P3: ''It was harder to switch mind off than other yoga as it (TSY) was easy.'' Another participant noted their initial difficulty to bring awareness to their body, P1: ''At the beginning it was really slow, it was hard to get into meditative state to sense the body... there was not enough to occupy the mind, I was distracted.''

Benefits described included greater attention regulation and emotion recognition capacities, P1: ''When it was a quicker pace it was easier to not be in my thoughts but in my body, used as an anchor.'', P2 ''... I realised I was doing a lot, I used concentration to focus in the body and pay attention to how I felt''. Participants also reported benefits of relaxation from present moment awareness, P1: ''I felt grounded and in my body at the end, I focused on myself unlike other classes where I just follow instructions'', P3: ''It was nice to do slow things... it was relaxing.'', P2: ''It was calming''.

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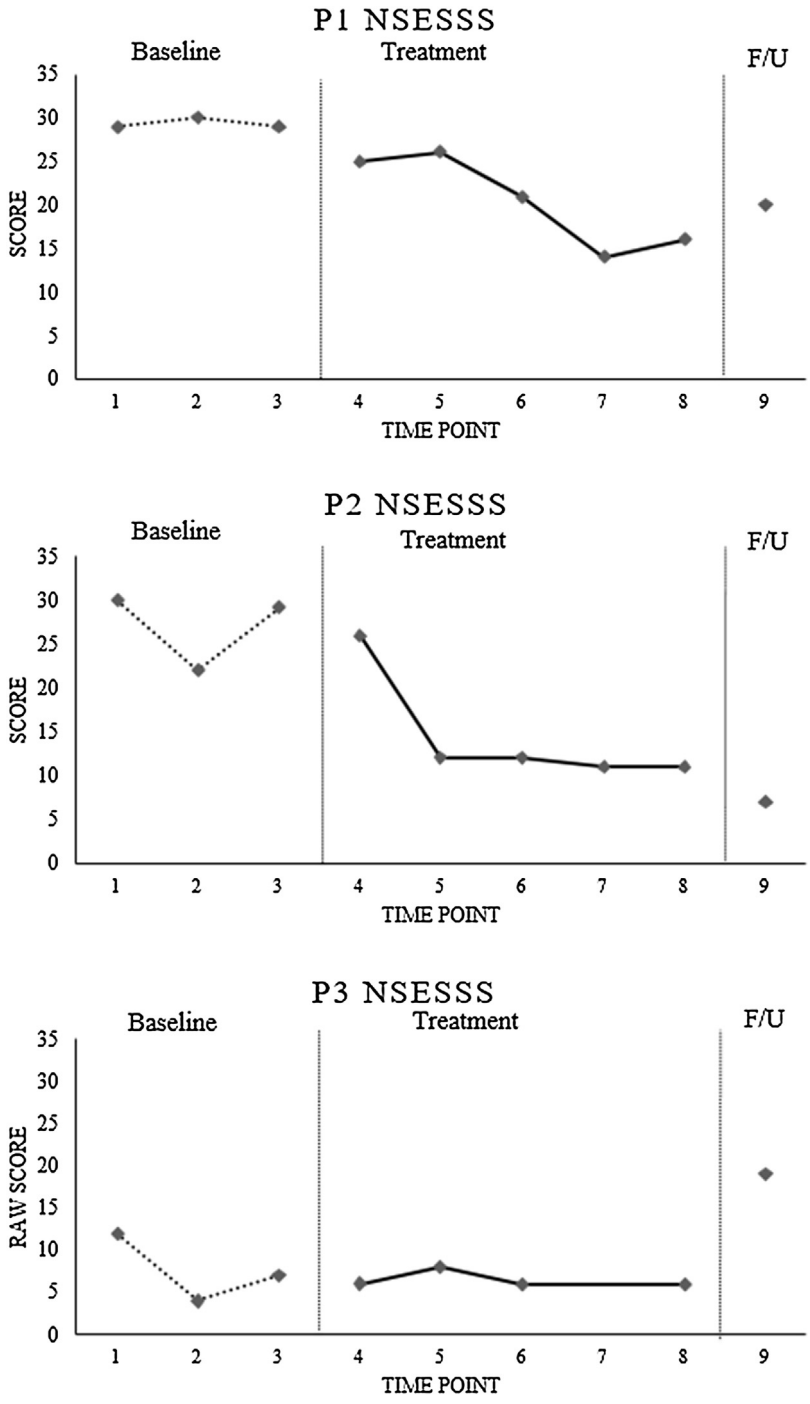

Fig. 1. Scores on the NSESSS for all participants.

4.2.2. Increased emotion regulation

Analysis revealed increased capacities for participants to regulate emotions and reduce negative affect. P1: "I found a calm during practice... a calm place where anxiety and depression can be put to the side." Another participant noted improved abilities to reduce negative cognitions, P2: "Some part of me needed to be told you can choose this or this... ties in with trauma and needing validation and reinforcement... no judging".

4.2.3. Generalisation of TSY benefits beyond sessions

Benefits of the yoga were found to generalise to the participant's daily lives, including increased attention regulation, increased emotion regulation capacities, and improved sleep quality. P3: "It (TSY) helped me focus with work", P2: "In the group (TSY) my negative self talk reduced, and this reduced at home.", P1: "I slept better the night of the TSY class... I fell asleep faster... I took inventory of myself and got back into my body." P2: "It (TSY) helped me cope with a panic attack... I took my layers off, slowed my outbreath, pressed my finger into my legs... I didn't dissociate..."

One participant described practising TSY every day at home for 15 minutes with meditation, she noted improved abilities to regulate attention of thoughts P1: "... I had done meditation for two years but the thoughts still came... the yoga (TSY) was good as an anchor, it gave motions to go through, it was a load off my mind to fight the thoughts." This improvement in attention regulation

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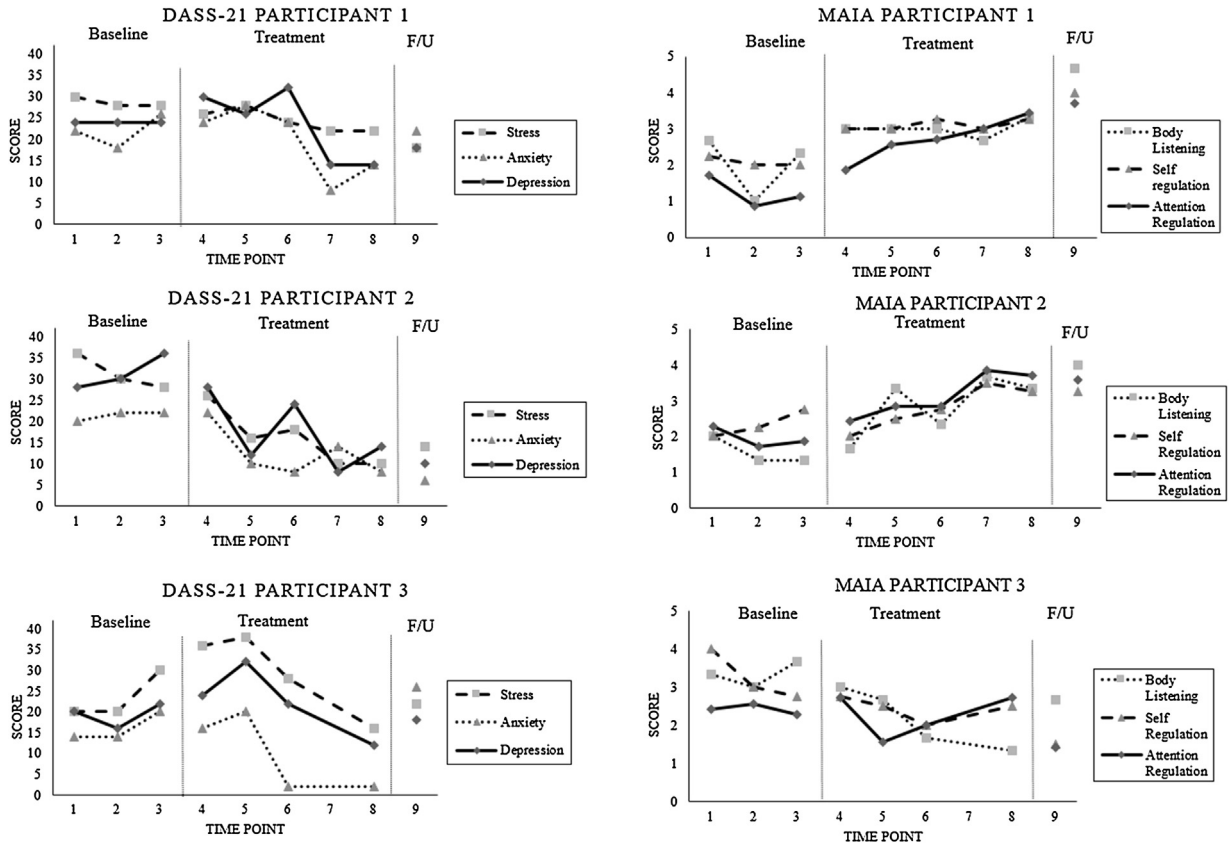

Fig. 2. Scores on the DASS-21 and MAIA subscales for all participants.

was also described by another participant, P2 "After eight weeks of the yoga (TSY) I was practising meditation more. . .it was helpful; I had tried to meditate for years".

5. Discussion

This case series sought to understand the impact of an eight-week Trauma Sensitive Yoga intervention on interoceptive awareness, as well as on trauma symptoms, depression, anxiety, and stress, for people with PTSD.

As hypothesized, interoceptive awareness capacities (Attention Regulation, Self-Regulation, and Body Listening) as measured by self-report measures, significantly increased for participants 1 and 2 post-yoga. This increase in interoceptive awareness was further supported by findings from the qualitative analysis. During post-yoga interviews, participants reported greater present moment awareness of thoughts, feelings, and body sensations. These improvements in interoception were reported to generalise beyond the yoga session to everyday life, including reported improvements in focusing on sensations of the body before sleep and during a panic attack.

Counter to hypothesis 1, participant 3 showed variable results on the interoceptive subscales. One potential factor why participant 3 did not show improvements in interoceptive awareness, is that participant 3 completed fewer yoga sessions (see Table 1). Research shows a correlation between frequency and duration of yoga practice and reductions and sustained improvement in PTSD symptomatology and depression (Price et al., 2017; Rhodes, Spinazzola, & Van der Kolk, 2016). The correct 'dose' of yoga required is an area for future research. Another potential factor why participant 3 did not show improvements in interoceptive awareness, is that experience of external stressors confounded her experience of the yoga sessions. Participant 3 in the post interview reported external stressors of illness within the family and study exams, correlating with her increase in Depression, Anxiety, and Stress scores up to time point 5.

The finding that participants 1 and 2 experienced increased interoceptive capacities post-yoga is consistent with previous research (Mehling et al., 2017; Rhodes, 2015; West et al., 2017). The current results from participant 1 and 2 suggest interoceptive awareness may be an important mechanism behind improvements in PTSD symptomology. These findings however are preliminary and require further investigation, with some discrepancies in results whereby participant 3 showed an increase in PTSD symptoms on the CAPS-5 pre- to post-yoga yet decrease on some interoceptive awareness scores. Research with larger participant numbers could elucidate whether this discrepancy is related to confounding factors or not. This study shows improvements in interoception occurred following a yoga program alone, prior research showed improvements in interoception following an integrative exercise program with yoga elements (Mehling et al., 2018).

This study provides preliminary support for somatic regulation and interoceptive awareness models in the treatment of PTSD (Van der Kolk et al., 2014). Treatments that improve interoceptive awareness could potentially target core difficulties associated with PTSD, being fluctuations between intrusive reliving of physical and mental trauma symptoms, and avoidance of bodily sensations or cognitions (Herman, 2015). That is, interoceptive awareness may increase the ability to therapeutically process trauma symptoms wihtout becoming overwhelmed. In this study, participants showed increased ability to focus on body sensations (Body Listening), sustain attention to these body sensations (Attention Regulation), and regulate distress by attending to body sensations (Self-Regulation). These increased interoceptive capacities could enable those affected by trauma to better engage in exposure/

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Table 3
Reliable Change Index (RCI) and clinical significance calculations for all psychometrics.

	DASS-21 subscales								MAIA subscales						Trauma measures			
	Depression		Anxiety		Stress		Attention regulation		Self-regulation		Body listening		NSESSS		CAPS-5			
Clinical Cut-off	14.22		12.27		20.66		2.91		3.05		2.83		16.62		37.02			
Participant/RCI	Pre-post	Pre-FU	Pre-Post	Pre-FU	Pre-post	Pre-FU	Pre-post	Pre-FU	Pre-post	Pre-FU	Pre-post	Pre-FU	Pre-post	Pre-FU	Pre-post	Pre-FU	Pre-post	Pre-FU
P1	3.73[b]	2.24[a]	2.88[a]	0.00	2.85[a]	4.56[b]	−6.53[b]	−7.37[b]	−2.74[b]	−4.50[b]	−3.19[b]	−6.40[b]	3.74[b]	2.62[a]	−0.38	−0.38		
P2	6.47[b]	7.96[b]	4.80[b]	5.52[b]	9.12[b]	7.41[b]	−5.25[b]	−4.83[b]	−2.16[b]	−2.16[b]	−4.24[b]	−5.85[b]	4.49[b]	5.62[b]	−1.52	−1.52		
P3	2.74[b]	0.50	5.04[b]	−3.60[b]	3.13[b]	0.57	-0.84	2.98[a]	1.76	1.76[a]	4.79[b]	1.58	0.47	−3.18[b]	8.36[b]	8.36[b]		

FU: follow-up; RCI: reliable change index.
[a] Reliable change.
[b] Clinically significant.

cognitive based therapies, and assist in effective regulation of emotions and behaviours.

The second hypothesis was that there would be a significant decrease in PTSD symptoms. The findings from the NSESSS and CAPS-5 suggest participation in the yoga intervention had an effect in reducing some but not all PTSD symptoms, no negative effects were observed. Participant 1 and 2 showed reliable decreases on the NSESSS both pre- to post-yoga, and at follow-up. These changes were clinically significant for both participants pre to post, and for participant 2 pre to follow-up. Based on the NSESSS severity ratings, participants 1 and 2 both moved from 'severe' PTSD symptoms pre-yoga, to 'mild' PTSD symptoms post-yoga (Kilpatrick et al., 2013). This demonstrates substantial and clinically meaningful decreases in PTSD symptoms from only 8 yoga sessions. The NSESSS results from participants 1 and 2 are in line with previous literature that shows significant reductions in PTSD symptoms following yoga interventions (Carter et al., 2013; Jindani et al., 2015; Van der Kolk et al., 2014). No clinically significant or reliable change was found for CAPS-5 PTSD interview data for participant 1 and 2 pre- to post-yoga. That is, there were no observed changes in PTSD diagnosis. This finding is inconsistent with previous literature. Inconsistencies from the PTSD measures in this study may be attributable to several factors, including the varying number of sessions participants attended, external confounding factors such as stressful life events, the complexity of the construct of PTSD that was assessed, or perhaps interoceptive awareness only has significant effects for specific PTSD criterion (Harris & Brown, 2010). Participant 3 showed reductions in PTSD symptoms based on the CAPS-5 pre to post intervention, however increased PTSD symptoms based on the NSESSS from pre to follow-up. A limitation of this study was that interview were conducted at post and not follow-up intervention, interviews at follow-up would have been beneficial to investigate discrepancies such as Participant 3's for PTSD symptoms.

Supporting the third hypothesis, anxiety, depression, and stress overall reliably and clinically significantly decreased for participants pre- to post-yoga. These findings are in line with previous research showing reductions in anxiety, depression, and stress following as little as 8 weeks of yoga (Jindani et al., 2015; Mccarthy et al., 2017; Van der Kolk et al., 2014).

5.1. Limitations and future research

Only three participants' data were used for analysis. This small number of participants limits the ability to generalise effects to trauma populations at large. In addition, 5 out of 6 participants had prior experience with yoga, further limiting generalizability. While, case series have limited generalizability to larger populations of patients, the use of this methodology has been acknowledged as an important platform to allow hypothesis to develop and pave the way for further advanced studies (Chan & Bhandari, 2011). Single-case designs allow novel hypotheses to be tested with as little as 3 participants, without subjecting a large number of participants to the research when the empirical evidence is not fully established (Barlow et al., 2009). Furthermore, Seldmeier et al. (2016) argue research that investigates meditation (which is a component of yoga and involves interoceptive awareness) is best done using single-case experimental designs as they take into account participants individual differences and specific experiences.

In addition, due to budget limitations the CAPS-5 interviews were conducted and scored by the first author and not an independent assessor, biases could therefore confound the scores. Finally, while interoceptive awareness, depression, anxiety, stress, and PTSD symptoms were all assessed in this study, the direct interaction and mediation between these factors could not be

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identified within the present study design and would be important for future research.

5.2. Conclusions

This research suggests interoceptive awareness may be an important mechanism related to improved mental health outcomes for those with PTSD subsequent an 8 week yoga intervention. Larger randomized control studies are needed to explore these preliminary findings and examine direct interaction effects.

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Disclosure of interest

The authors declare that they have no competing interest.

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