



Yogic Breathing and Mindfulness as Stress Coping Mediate Positive Health Outcomes of Yoga

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Abstract

Objectives Despite accumulating research on yoga and its positive impact on both physiological and psychological health, it is still unclear *how* yoga improves health. Two central components of yoga, *yogic breathing* and *mindfulness*, may be important mechanisms by which individuals learn to cope with their daily stressors, and thereby reduce their risk of developing stress-related illness. In this study, we experimentally tested whether yogic breathing as a stress coping mechanism and increased mindfulness mediates the psychological health benefits of a yoga intervention

Methods Seventy-one middle-aged adults (78% women; $M_{age} 53.5 \pm 6.9$) who self-rated as moderately stressed were randomly assigned to either a control group or a 5-week yoga intervention called the Yoga and Mindfulness Intervention (YOMI) program. The YOMI combines 60 min of yin yoga practice with 30 min of psychoeducation, administered twice weekly; participants also completed a 5-min breathing exercise as homework daily.

Results The YOMI group showed greater reductions in anxiety, depression, and sleep problems compared with controls (R^2 varied between .09 to .23), and these reductions were statistically mediated by increased use of yogic breathing and a related increase in participants' overall mindfulness.

Conclusions These mediation results provide new insights into how yoga improves psychological health and suggests promising implications for policymakers aimed at improving public health.

Keywords Stress coping · Mindfulness · Breathing · Yoga · Health · Mediation

Practicing yoga has beneficial health effects. For example, yoga interventions can reduce perceived stress (Chiesa and Serretti 2009; Creswell et al. 2014; Gawrysiak et al. 2016; Goyal et al. 2014; Sharma 2014) and stress-related mental illness such as anxiety (Bamber and Kraenzle Schneider 2016; Call et al. 2014; Hylander et al. 2017) and depression (Hofmann et al. 2010; Janakiramaiah et al. 2000; Streeter et al.

2010). Yoga can also have physiological benefits such as lowering blood pressure and cortisol levels (Salmon et al. 2009; Thirthalli et al. 2013), and it can improve overall well-being (Goyal et al. 2014). Nevertheless, we still know very little about the mechanisms underlying these positive health effects, that is, *how* yoga improves health. Although researchers have examined some potential mediators, including mindfulness, self-compassion (Gard et al. 2012), and positive affect (Kiecolt-Glaser et al. 2010), a recent systematic review by Riley and Park (2015) revealed that there are surprisingly few rigorous empirical studies testing mediating mechanisms.

A common denominator for the health benefits of yoga is that they relate to the concept of “stress.” Stress is defined as a pattern of appraisals, physiological responses, and behavioral tendencies that occur when a person perceives the demands of a situation exceed his or her resources to handle those demands (Lazarus 1999). Although experiencing moderate amounts of stress is rarely a health risk, chronic exposure to even small daily hassles, or acute exposure to extreme stressors, can have pronounced negative health effects (An

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et al. 2015; Cohen et al. 2007; Machado et al. 2014). It has been suggested that practicing yoga helps people develop better stress coping techniques, thereby reducing the negative health effects of chronic stress (e.g., Auerbach 1989; Heilbronn 1992; Holahan and Moos 1990; Hylander et al. 2017; Kinser et al. 2013; Maddux et al. 2018; Rizzolo et al. 2009; Strentz and Auerbach 1988). Yoga may be particularly helpful in improving emotion-focused stress coping, which involves reducing physiological arousal through relaxation, cognitively reappraising stressors, or learning to accept what cannot be changed (Amirkhan 1990; Auerbach 1989; Carver et al. 1989; Holahan and Moos 1990; Lazarus and Folkman 1984; Lazarus and Lazarus 2006; Strentz and Auerbach 1988;). It has specifically been suggested that yogic breathing and mindfulness—two key components of yoga—may help people emotionally cope better with stress (Brown and Gerbarg 2009; Christmann et al. 2017), which could potentially mediate the putative health benefits.

In Western countries, yoga practice typically entails performing sequences of physical postures combined with slow and highly mindful breathing. Kabat-Zinn (2007, p. 4) defined mindfulness as “paying attention in a particular way: on purpose, in the present moment, and non-judgmentally.” While certain yoga postures can be uncomfortable and/or disorienting, the yoga instructor coaches the practitioner to mindfully focus on the breathing and “breathe through” discomfort rather than trying to avoid it or fight it (Brown and Gerbarg 2009). Through deliberate and persistent practice, individuals learn to direct their attention to changes in the breath and also moment-by-moment bodily sensations, thoughts, and emotions, as these phenomena arise (Desikachar 2015). Yogic breathing thus acts as a link between mind and body and may be viewed as an anchor point for cultivating mindfulness in one’s daily life (Salmon et al. 2009). Possibly, the practice of mindful yogic breathing teaches individuals to cope better with daily stressors, thereby reducing stress and stress-related illness. Mindful stress coping can involve allowing oneself to perceive and endure stressors as they are, without avoidance, judgment, or self-criticism, and intentionally choosing one’s actions instead of resorting to impulsive reactions (Baer et al. 2006; Gunaratana 2011). By using breathing and learning to stay in the present and not be pulled away by thoughts, mindful breathing may function as a tool to learn how to recognize triggers of unwanted feelings and situations and acting more in line with one’s values and goals (Hayes et al. 1999; Morone et al. 2012).

Although there are currently no empirical studies in the literature that have empirically tested if mindful yogic breathing to cope with stress mediates the health benefits of yoga, there is evidence that links breathing and mindfulness to stress reduction and improved stress-related health. Brief mindfulness meditation sessions decrease anxiety and negative mood

(Zeidan et al. 2010; McClintock and Anderson 2015) and increase mindfulness that relates to lowered distress (Kiken et al. 2015). There is evidence to show that slow, deep breathing has physiological benefits, helping regulate imbalances in the autonomic nervous system and stimulating parasympathetic activity to produce sensations of relaxation (Brown and Gerbarg 2009; Gilbert 1999; Grilley 2002; Sovik 2000). It also influences a broad range of mental and physical disorders, such as anxiety (e.g., Cho et al. 2016; Doria et al. 2015), depression (e.g., Sharma et al. 2017; Zope and Zope 2013), and cardiovascular diseases (Chodzinski and Yucha 2001; Harinath et al. 2004). Interestingly, a recent study in mice found that the breathing center might influence higher order brain functions; the ablation of *Cdh9/Dbx1* preBötzing complex neurons lowered respiratory rates secondary to an increase in slow breaths and a reduction in rapid breaths. This change in breathing pattern was accompanied by a shift towards calm behaviors, which indicates the possibility of a direct pathway through which breathing influences mental state and thereby produces behavioral change (Yackle et al. 2017). Calm mindful breathing has been incorporated in healthcare to help individuals cope with extreme stressors such as childbirth (e.g., Lothian 2011), and Sherman et al. (2013) presented qualitative evidence of the positive effects of yogic breathing on stress.

In the current study, we test the notion that changes in yogic breathing and mindfulness, as emotion-focused stress coping techniques, taught and cultivated in yoga practice, may improve mental health. Since yoga practice teaches breathing and mindfulness, we propose that “off the mat” pausing to take deep, calm breaths while experiencing an acute stressor may have an immediate calming effect on the mind and body, and simultaneously enable a more mindful outlook on the stressor and how it can be handled. We expect that the effect of the Yoga and Mindfulness Intervention (YOMI; Hylander et al. 2017) on positive (i.e., life satisfaction, harmony in life) and negative (i.e., perceived stress, anxiety, depression, sleep problems, general health problems) aspects of mental health is mediated via increases in yogic breathing as a stress coping strategy and mindfulness.

Method

Participants

Participants were primarily recruited from the general population through advertisements in local newspapers between November 20 and December 15, 2015. The advertisements explicitly asked people who were experiencing chronic stress in their everyday life to participate in a research study aimed at investigating the effect of yoga on stress and health.

As the flow diagram in Fig. 1 shows, every individual who registered for the study ($n = 200$) was screened using the following inclusion criteria: (a) experiencing stress in everyday life, (b) aged 40–65 years, (c) physically fit enough to perform regular yin yoga postures (e.g., no knee or back injuries), and (d) ability to participate during the intervention period. In accordance with recommendations by Cohen et al. (1983), we used four selected items from the Perceived Stress Scale (PSS; Cohen et al. 1983) to determine participants' stress level over the telephone. Participants with a score of 8 or higher (on a range of 0 to 16) on these items were included in the study. Exclusion criteria were (a) previous regular yoga or mindfulness experience (more than 6 months of practice before the study began) and/or (b) current psychological or psychopharmacological treatment. Each participant was randomized to one of the two following conditions: intervention group or control.

Procedures

This study was conducted as a parallel-group, randomized controlled trial with repeated measures involving two data collection points. Randomization was performed at the individual participant level using a web-based tool called Research Randomizer (Urbaniak and Plous 2013).

Participants were randomly assigned either to the intervention or control group.

The yoga intervention used—the YOMI program (from here on referred to as the yoga intervention)—is a psychoeducational training and physical practice-based program that bridges knowledge from evidence-based psychotherapy with the practice of mindfulness and yin yoga (Hylander et al. 2017). It has been shown to reduce stress, depression, anxiety, sleep problems, and the biomarker adrenomedullin (Daukantaitė et al. 2018; Hylander et al. 2017), the latter being a strong predictor of non-communicable disease and premature mortality (Belting et al. 2012; Melander et al. 2009). Yin yoga is a slow-paced form of yoga that involves holding each posture for a long time (about 3 min), while calmly breathing and trying to mindfully focus one's attention breathing and any physical sensations that arise without judgment. The yoga intervention was guided by two trained yoga instructors and licensed psychologists who were hired as independent consultants by the research group. The instructors were unaware of the study's hypotheses and measures. Participants who were randomly assigned to the intervention group attended ten sessions twice weekly over the course of 5 weeks (see Table 1 for a summary of the topics). The length of each session was approximately

Fig. 1 Flow diagram

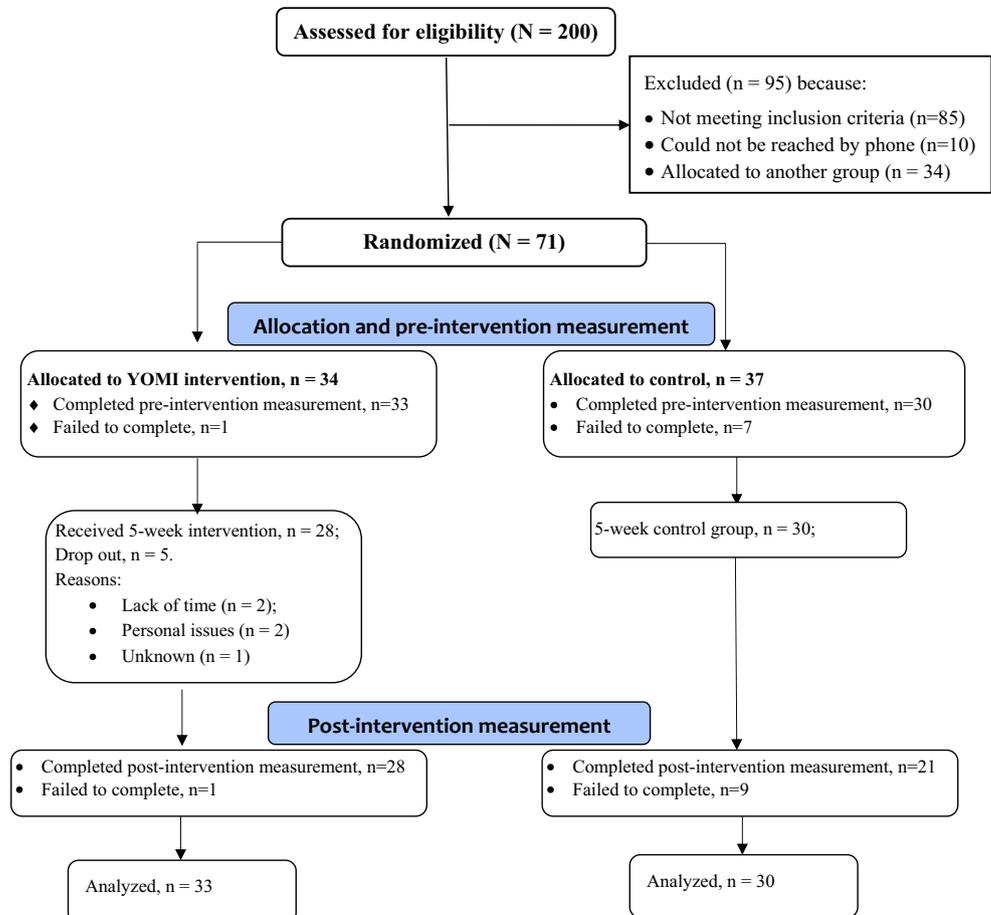


Table 1 Topic of each session of the YOMI program

Session	Topic	Short summary of content	
Week 1	Session 1	Presentation and introduction	Introductory lecture to yoga and mindfulness, stress, yin, and yang. Practice introducing the yin yoga program and different asanas
	Session 2	Observation and breathing	Lecture on the breath, its physiology, and function during stress and worry. Introduction to an observational mindset. Breathing exercise “counting breath,” body scan with physical tension and relaxation. Practice focused on breathing and observing thoughts, emotions, and bodily sensations
Week 2	Session 3	Our five senses	Introduction to our five senses. Lecture on non-reactive observation and theory of grasping-rejecting. Breathing exercise “ujjayi pranayama.” Co-breathing exercise. Mindfulness eating exercise focusing on exploring all five senses. Practice focusing on observing all five senses, physical aspects of yin yoga
	Session 4	Balance	Lecture on finding balance between activity and restoration, the sympathetic and parasympathetic nervous system. Introducing the three emotion regulation systems and the concept of function and form. Breathing exercise “Nadi Shodhana.” Exercise “Three circles.” Practice focusing on self-compassion, using the concepts of function and form
Week 3	Session 5	YOMI practice	Recap of lectures from sessions 1 to 4. Meditation on breathing and letting go. Practice focusing on exploring one’s practice
	Session 6	Introduction to acceptance	Lecture introducing the definition of acceptance, true/false acceptance, introducing defusion. Mindfulness exercise on observing automatic thoughts. Meditation on passing clouds. Meditation on acceptance. Practice focusing on acting non-reactive and non-judgmental
Week 4	Session 7	Applications of acceptance	Lecture on acceptance, applications of acceptance, functional contextualism, and compassion. Introduction of “SOAS.” Compassion meditation. Practice focusing on acceptance, letting go, using SOAS and compassion
	Session 8	Self-care	Lecture on self-care, the concepts of form and function. Introduction of tactile touch as calming tool. Tactile massage, self-compassion meditation. Practice focusing on exploring self-care using self-compassion and previously introduced tools
Week 5	Session 9	YOMI practice	Recap of lectures from sessions 6 to 8. Meditation on conscious breath and happiness. Practice focusing on silence and being in stillness
	Session 10	YOMI in the everyday life	Lecture on how the YOMI practice can be used in the everyday life. Introducing the concept of “monkey mind.” Walking meditation. Practice focusing on combining all tools and concepts of the program

90 min, with 30 min of lecture on a weekly topic (see Table 1) followed by 60 min of guided yin yoga. The pre-intervention (baseline) assessment was performed approximately 1 week before the first intervention session (February 1–12, 2016). The post-intervention assessment was conducted approximately a week after the interventions were finished (March 21–April 1, 2016).

The intervention group was also assigned homework, which involved listening to an audio CD daily that guided them through a 5-min breathing exercise that mimicked the type of breathing used during yoga. The purpose of the homework was to help participants learn and incorporate deliberate breathing into their everyday lives. Intervention group participants were asked to record the time (in minutes) that they

Table 2 Descriptive statistics of the participants

Variable	Group		Test statistic
	YOMI (<i>n</i> = 33)	Control (<i>n</i> = 30)	
Gender (women, <i>n</i> %)	26 (79%)	23 (77%)	$\chi^2 = 0.04, p = .840$
Age (M±SD)	54.4 ± 7.0	52.6 ± 6.8	$t_{61} = 1.01, p = .315$
Education (<i>n</i> %)			
High school degree	11 (33.3%)	12 (40%)	$\chi^2 = 0.31, p = .583$
Bachelor’s/master’s degree or other	22 (66.7%)	18 (60%)	
Marital status (<i>n</i> %)			
Single	9 (27.3%)	5 (16.7%)	$\chi^2 = 1.02, p = .312$
Married/co-habiting	24 (72.7%)	25 (83.3%)	
Employment status (<i>n</i> %)			
Full-/part-time job	28 (84.8%)	27 (90%)	$\chi^2 = 0.38, p = .540$
Unemployed or other	5 (15.2%)	3 (10%)	

practiced the daily breathing assignment and to hand in their timesheets after the intervention.

Participants assigned to the control condition were instructed to not practice yoga during the study period: however, they were offered a 3-hour yoga workshop (and a yoga mat) after study completion as compensation. Participants in the control group completed the pre- and post-intervention assessments about 1 week before (February 15–26, 2016) and after (April 4–16, 2016), respectively, the waiting period.

Using a unique research code, participants accessed and completed study's measures online via a confidential and secure web-survey housed at Lund University. The data presented here were extrapolated from a larger research project, which in parts are presented elsewhere (Daukantaitė et al. 2018)

Measures

Perceived Stress Scale The PSS (Cohen et al. 1983) is a 10-item scale for measuring the degree to which situations in one's life are appraised as stressful. The items (e.g., *In the last month, how often have you felt that you were unable to control the important things in your life?*) are rated on a 5-point scale from 0 (never) to 4 (very often) with a higher score indicating higher levels of perceived stress. It has shown good internal consistency, with Cronbach's alpha coefficients ranging from .80 to .86 (Nordin and Nordin 2013). In this study, the alpha values were .85 at the first measurement (T1) and .80 at the second (T2).

Yogic Breathing as Stress Coping Scale We constructed a 4-item measure called the Yogic Breathing as Stress Coping Scale (YBSC) to evaluate how often individuals use breathing as a coping strategy when they experience a stressful event. The instruction, *What do you generally do when you experience stressful events?* was adapted from the COPE scale (Carver et al. 1989). The four items are as follows: *I take several deep, calming breaths; I breathe deeper and calmer; I focus on my breathing; and I concentrate on my breath.* All four items are rated on a five-point Likert scale ranging from 1 (I usually don't do this at all) to 5 (I usually do this a lot) with a higher score indicating a larger focus on deliberate breathing when experiencing a stressful event. The Cronbach's alpha values in this study were .89 (T1) and .95 (T2).

Five Facet Mindfulness Questionnaire-Short Form The Five Facet Mindfulness Questionnaire-Short Form (FFMQ-SF) (Bohlmeijer et al. 2011) is a 24-item scale derived from the original FFMQ scale (Baer et al. 2006) designed to measure five facets of mindfulness: observing (4 items; e.g., *I notice the smells and aromas of things*), describing (5 items; e.g., *Even when I'm feeling terribly upset, I can find a way to put it into words*), acting with awareness (5 items; e.g., *I find*

myself doing things without paying attention), non-judging (5 items; e.g., *I make judgments about whether my thoughts are good or bad*), and non-reactivity (5 items; e.g., *When I have distressing thoughts or images, I feel calm soon after*). The items are rated on a five-point scale from 1 (never or very rarely true) to 5 (very often or always true) with a higher score indicating higher levels of mindfulness. The whole scale and its subscales have previously shown satisfactory Cronbach's alpha values, which ranged from 0.75 to 0.87 (Bohlmeijer et al. 2011). In this study, only the whole scale was used. The Cronbach's alpha values for the whole scale in this study were .89 (T1) and .91 (T2).

General Health Questionnaire The General Health Questionnaire (GHQ) (Golderberg and Williams 1988) comprises 12 items, each assessing the severity of a mental problem over the past few weeks on a 4-point Likert-type scale (0–3). These scores generate a total score ranging from 0 to 36. Positive items are scored from 0 (always) to 3 (never), while negative ones are scored from 3 (always) to 0 (never), so that higher scores indicate worse health. The instrument is considered reliable and has been translated into 38 different languages. The Cronbach's alpha coefficient for the GHQ ranged from 0.82 to 0.86 in Golderberg and Williams (1988). In this study, the alpha values were .85 (T1) and .81 (T2).

Life Satisfaction Life satisfaction was measured using three questions: (1) *How satisfied are you with your current life?* (2) *To what extent are you pleased with your present life?* and (3) *How do you value your life?* All the questions were rated on a 7-point scale from 1 (I'm not satisfied with it/Not at all/Very bad) to 7 (I'm totally satisfied with it/To a very high extent/Very good) with a higher score indicating higher levels of life satisfaction. In the present study, the Cronbach's alpha values were .90 (T1) and .96 (T2).

The Harmony in Life Scale The Harmony in Life Scale (HILS) (Kjell et al. 2016) assesses a global sense of harmony in one's life and comprises 5 statements (e.g., *Most aspects of my life are in balance*). The participants are asked to indicate their degree of agreement with each statement on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree) with a higher score indicating higher levels of harmony in life. A total harmony score is calculated by summing the scores for the 5 statements. The HILS has shown high internal consistency (Cronbach's alpha = .91; Vainio and Daukantaitė 2016), and in this study, the Cronbach's alpha values were .82 (T1) and .91 (T2).

The Hospital Anxiety and Depression Scale The Hospital Anxiety and Depression Scale (HADS) (Zigmond and Snaith 1983) is a 14-item scale used to assess levels of

anxiety and depression. Seven of the items relate to anxiety and seven relate to depression with a higher score indicating higher levels of anxiety and depression, respectively. The items can be summed to arrive at a total scale score, or simply summed for each subscale. Each item is scored on a scale ranging from 0 to 3. The HADS has been used extensively, and its psychometric properties are well-established (Bjelland et al. 2002). The average Cronbach's alpha coefficients for the anxiety and depression subscales are .83 and .82, respectively. The Cronbach's alpha values in this study were .82 (T1) and .85 (T2) for anxiety and .75 for depression (at both time points).

The Insomnia Severity Index The Insomnia Severity Index (ISI) (Morin 1993) was designed as a brief screening measure of insomnia that can also be used as an outcome in intervention research. The ISI consists of seven items evaluating severity of sleep onset and maintenance (e.g., middle and early morning awakening) difficulties, satisfaction with current sleep pattern, interference of insomnia with daily functioning, occurrence of impairments attributed to insomnia, and the degree of concern caused by insomnia. The items are rated on a five-point Likert scale from 0 (not at all) to 4 (extremely) with a higher score indicating higher levels of sleep problems. The scale has shown good internal consistency (Cronbach's alpha = .76; Bastien et al. 2001). The alpha values in this study were .90 at both time points.

Data Analyses

The preliminary data checks revealed no violations of the assumptions of normality, homogeneity of variances, linearity, and homogeneity of regression slopes. Between-group comparisons of participants' baseline characteristics were conducted using independent samples *t* test and chi-square tests for continuous and categorical variables, respectively. Pearson correlations were calculated between pre-post changes in psychological outcomes. All of the above-mentioned analyses were conducted in SPSS Statistics 24 (IBM Corp., Armonk, NY). The effects of the interventions on the outcomes were studied by estimating the models with the full-information maximum likelihood method in SPSS AMOS, which enabled intent-to-treat analyses. The outcome variables were calculated as the difference between pre-test and post-test scores, and the predictor was a dummy coded group variable (1 = intervention group, 0 = control group).

The mediation analysis with the macro PROCESS by Preacher and Hayes (2008) was used to estimate whether there was an indirect effect of the yoga intervention on health outcomes (i.e., perceived stress, life satisfaction, harmony in life, general health problems, anxiety, depression, and sleep problems) through increased yogic breathing (as a stress coping technique) and mindfulness (see Fig. 2). The macro

PROCESS implements a bootstrapping procedure to create confidence intervals (CI) for the indirect effects in the mediation model. An indirect effect is considered significant if the CI does not include zero. This method focuses on the size and direction of the indirect effects of potential mediators rather than on the significance of the direct effects (Preacher and Hayes 2008). It has been recommended over the causal step method, as it has higher power and relies on fewer assumptions (MacKinnon et al. 2002). According to Zhao et al. (2010), establishing mediation requires testing whether the indirect effect is significant.

Results

Descriptive Statistics, Randomization Check, and Attrition Analysis

The data of 64 participants were analyzed: 34 (79.4% female) in the intervention group and 30 (76.7% female) in the control group. The mean age was 53.6 (intervention group: $M = 54.5$, $SD = 6.9$, range = 42–67; control group: $M = 52.6$, $SD = 6.8$, range = 41–64). The majority of participants worked full-time (82.4% and 90% in the intervention and control groups, respectively) and were highly educated (i.e., 55.8% and 56.7% in the intervention and control groups, respectively, had a bachelor/master's degree). As shown in Table 2, there were no statistically significant differences between the experimental and control groups on any of the baseline characteristics. Additionally, Table 3 shows no significant group differences in the outcome variables at T1, except for anxiety, $t(61) = 2.47$, $p < .05$.

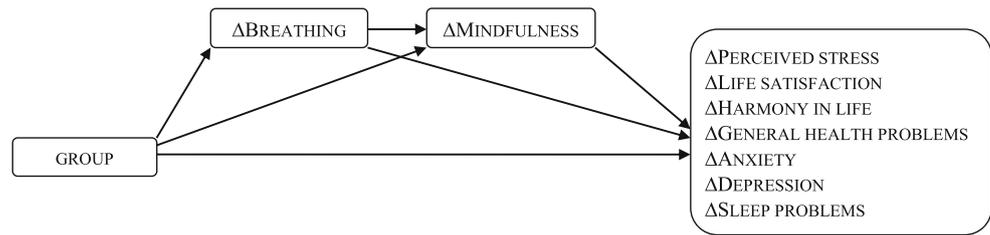
Sixty-three individuals (33 in the intervention group, 30 in the control group) had data for at least one of the two data collection points, whereas 49 individuals (28 and 21 in the intervention and control groups, respectively) had complete data at both time points. An attrition analysis was conducted to determine if those who did not complete the second assessment differed significantly in their pre-test scores from those who completed both assessments. The results revealed no significant differences between these two groups in the pre-test scores for any of the variables ($p > .05$).

Finally, 27 (96.4%) of the 28 completers of the intervention group returned the daily breathing assignment sheets, which reported a mean of 321.96 ($SD = 198.64$) minutes of total breathing exercise time over 5 weeks. Participants attended an average of 8.5 sessions ($SD = 1.5$; range 5–10).

Between-Group Comparisons of Study Outcomes

As shown in Table 4, compared with the control group, the intervention group showed significantly greater reductions in perceived stress ($\beta = -0.32$, $p = .020$), anxiety ($\beta = -0.47$, $p <$

Fig. 2 Conceptual mediation model tested in the present study. We tested separate mediation models for each of the dependent variables



.001), depression ($\beta = -0.27, p = .048$), general health problems ($\beta = -0.30, p = .027$), and sleep problems ($\beta = -0.45, p < .001$), as well as significantly greater increases in yogic breathing ($\beta = 0.48, p < .001$), mindfulness ($\beta = 0.29, p < .033$), and life satisfaction ($\beta = 0.30, p = .027$).

Yogic Breathing and Mindfulness as Potential Mediators

Table 5 displays the zero-order correlations between the potential mediators and outcomes. The correlation between pre-post changes in yogic breathing and mindfulness was $r = .42, p = .003$.

The mediation analysis estimated whether there was an indirect effect of the YOMI program on health outcomes through increased yogic breathing (as a stress coping technique) and mindfulness. Table 6 and Fig. 3 show that significant indirect effects were found for anxiety, depression, and sleep problems, suggesting that participants in the intervention group reported a significant increase in usage of yogic breathing as a stress coping technique ($a_1 = 3.00, p = .001$), which in turn led to increased mindfulness ($d_{21} = 1.14, p = .05$) and decreased levels of anxiety ($b_2 = -0.15, p = .002$), depression ($b_2 = -0.12, p = .006$), and sleep problems ($b_2 = -0.16, p = .02$). The indirect effect was not significant for stress, although

the total indirect effect was. This suggests that the indirect effect via our selected mediators was not particularly strong, even though the sum of the indirect effects was significant.

However, when we tested separate mediation models for the effect of the YOMI program on stress with yogic breathing and mindfulness as single mediators, significant indirect effects were found in both cases (95% CI – 5.11 to – 0.47 and – 3.42 to – 0.03 for breathing and mindfulness, respectively).

Table 3 Means (standard deviations) and results of independent samples *t* tests (two-tailed) for outcome variables at T1 ($n = 63$)

	M (SD)		<i>t</i> test	
	YOMI	Controls	<i>t</i> (61)	<i>p</i>
PSS	20.64 (5.87)	19.17 (6.21)	0.97	0.34
Yogic breathing	8.36 (2.89)	7.80 (2.78)	0.79	0.44
FFMQ, total	73.09 (12.24)	77.1 (13.38)	- 1.24	0.22
Life satisfaction	13.79 (4.57)	15.00 (2.88)	- 1.27	0.21
HILS	20.27 (6.51)	22.93 (5.91)	- 1.69	0.10
GHQ	26.12 (6.53)	23.37 (5.89)	1.75	0.09
HADS anxiety	11.27 (3.61)	8.87 (4.13)	2.47	0.02
HADS depression	6.36 (3.33)	5.60 (3.27)	0.92	0.36
ISI	20.24 (5.90)	18.10 (6.67)	1.35	0.18

PSS, the Perceived Stress Scale; FFMQ, the Five Factors Mindfulness Questionnaire; HILS, the Harmony in Life Scale; GHQ, the General Health Questionnaire; HADS, the Hospital Anxiety and Depression Scale; ISI, the Insomnia Severity Index

Table 4 Results of regression analyses with group as predictor and pre-post changes in outcome variables as dependent variables

	<i>B</i>	SE <i>B</i>	β	
ΔPerceived stress				$R^2 = .10$
Constant	- 3.76	1.21		
Group	- 3.88	1.67	- .32*	
ΔYogic breathing				$R^2 = .23$
Constant	1.00	0.57		
Group	3.00	0.78	.48***	
ΔMindfulness				$R^2 = .09$
Constant	3.62	1.94		
Group	5.70	2.68	.29*	
ΔLife satisfaction				$R^2 = .09$
Constant	0.81	0.68		
Group	2.08	0.94	.30*	
ΔHarmony in life				$R^2 = .03$
Constant	2.57	0.90		
Group	1.54	1.24	.18	
ΔGeneral health problems				$R^2 = .09$
Constant	- 2.10	0.82		
Group	- 2.51	1.14	- .30*	
ΔAnxiety				$R^2 = .22$
Constant	- 0.86	0.66		
Group	- 3.32	0.91	- .47***	
ΔDepression				$R^2 = .08$
Constant	- 1.14	0.60		
Group	- 1.64	0.83	- .27*	
ΔSleep problems				$R^2 = .20$
Constant	- 0.62	0.87		
Group	- 4.20	1.20	- .45***	

* $p < .05$; ** $p < .01$; *** $p < .001$. Δ indicates pre-post changes

Table 5 Pearson correlations between pre-post changes in yogic breathing and mindfulness (potential mediators) and other study outcomes

Change in	Yogic breathing	Mindfulness
Perceived stress	– .45***	– .37**
General health problems	– .26 [#]	– .35*
Life satisfaction	.16	.16
Harmony in life	.25 [#]	.32*
Anxiety	– .45***	– .56***
Depression	– .38**	– .50***
Sleep problems	– .41**	– .47***

[#] $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

Discussion

This randomized controlled trial expands previous research on the possible mechanisms of how yoga improves health (Riley and Park 2015) by suggesting that practicing yoga helps people develop better stress coping techniques. This, in turn, may reduce the health risks associated with stress and improve various aspects of mental health. In line with our expectations, after the 5-week yoga and mindfulness intervention (YOMI,

Hylander et al. 2017), participants reported significant increases in using yogic breathing to cope with stressful events as compared to the control group. Further, this increase in yogic breathing as stress coping was related to increases in mindfulness as compared to the control group.

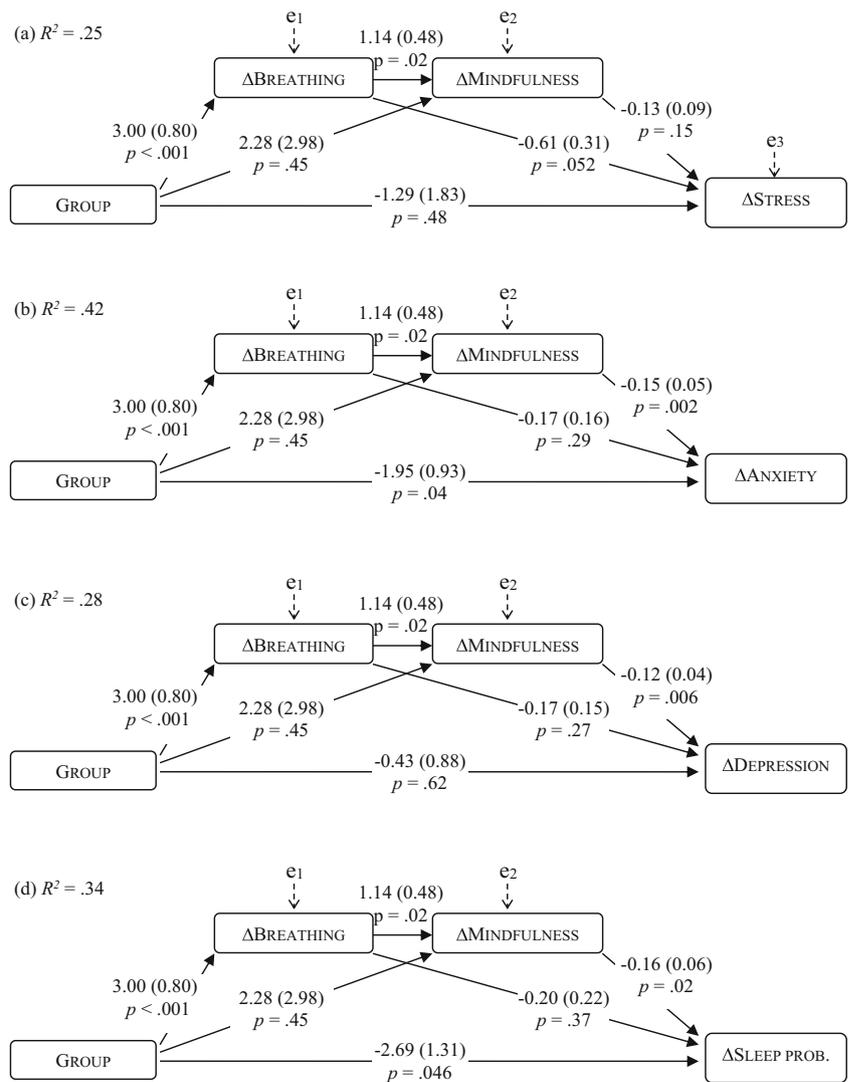
Importantly, the increases in yogic breathing and mindfulness significantly mediated reductions in three negative health effects associated with stress: anxiety, depression, and sleep problems. This is important because anxiety and depression are highly deleterious illnesses in themselves (Isometsa 2014; Kanwar et al. 2013) and may also serve as identifiable risk factors in the development of physical illness such as coronary heart disease (Gan et al. 2014) and increased mortality risk for comorbid conditions (Panagioti et al. 2014). Sleep problems, on the other hand, can contribute to a wide range of physiological and mental illnesses (Irwin 2015). For example, insomnia with short sleep duration is associated with a higher risk of hypertension, impaired heart rate variability, diabetes, neurocognitive impairment, and mortality (Vgontzas et al. 2013). Mere sleep complaints have also been found to contribute to the risk of cardiovascular disease risk (Mullington et al. 2009), cancer (Sigurdardottir et al. 2013), and depression (Baglioni et al. 2011). Thus, the insight that practicing yoga helps people better cope with stress and thereby improve their

Table 6 Summary of mediation results for the mediation models

	Indirect effects via			Total
	Δ Yogic breathing and Δ Mindfulness	Δ Yogic breathing	Δ Mindfulness	
Group → Δ Stress				
B (boot SE)	– 0.45 (0.49)	– 1.84 (1.23)	– 0.30 (0.47)	– 2.59 (1.18)
95% boot CI	– 2.13 to 0.07	– 4.91 to 0.08	– 1.94 to 0.25	– 5.34 to –0.67
Group → Δ Life satisfaction				
B (boot SE)	0.10 (0.22)	– 0.03 (0.88)	0.07 (0.20)	0.13 (0.80)
95% boot CI	– 0.18 to 0.81	– 1.77 to 1.70	– 0.12 to 0.88	– 1.39 to 1.83
Group → Δ Harmony in life				
B (boot SE)	0.38 (0.32)	0.55 (0.82)	0.26 (0.35)	1.19 (0.77)
95% boot CI	– 0.00 to 1.49	– 0.78 to 2.45	– 0.21 to 1.34	– 0.07 to 3.10
Group → Δ General health problems				
B (boot SE)	– 0.39 (0.36)	– 0.22 (0.82)	– 0.26 (0.41)	– 0.86 (0.73)
95% boot CI	– 1.54 to 0.08	– 1.95 to 1.34	– 1.56 to 0.25	– 2.58 to 0.35
Group → Δ Anxiety				
B (boot SE)	– 0.52 (0.36)	– 0.50 (0.50)	– 0.34 (0.40)	– 1.37 (0.64)
95% boot CI	– 1.52 to –0.05	– 1.64 to 0.37	– 1.20 to 0.40	– 2.79 to –0.24
Group → Δ Depression				
B (boot SE)	– 0.43 (0.26)	– 0.50 (0.60)	– 0.28 (0.33)	– 1.21 (0.66)
95% boot CI	– 1.21 to –0.08	– 1.81 to 0.60	– 1.11 to 0.30	– 2.72 to –0.10
Group → Δ Sleep problems				
B (boot SE)	– 0.54 (0.35)	– 0.61 (0.76)	– 0.36 (0.45)	– 1.51 (0.93)
95% boot CI	– 1.48 to –0.07	– 2.31 to 0.67	– 1.53 to 0.28	– 3.64 to –0.07

Italic values indicate significant results; Δ indicates pre-post changes

Fig. 3 Mediation models for the effect of group on **a** perceived stress, **b** anxiety, **c** depression, and **d** sleep problems mediated by breathing and mindfulness (the sum of all facets of the five facet mindfulness questionnaire). Values are unstandardized regression coefficients. *** $p < .001$; ** $p < .01$; * $p < .05$; # $p < .10$



health might have important implications for policymakers aimed at improving public health.

The results of this study do, in fact, indicate that yoga improves health by way of improvements in stress coping. After 5 weeks of learning yoga, practitioners were more likely to take deep, focused calm breaths when experiencing stress, which related to increases in mindfulness, and these changes in stress coping improved their psychological health. That yoga practitioners appear to learn to incorporate yogic breathing to help cope with their daily stressors aligns with the putative effects suggested by Schmalzl et al. (2015, p.7): “practicing breath awareness and conscious breath regulation in the context of movement has the potential of facilitating the use of supportive breathing patterns in everyday life situations.”

Unexpectedly, when yogic breathing and mindfulness were simultaneously tested as mediators in the statistical model, only yogic breathing showed a tendency to mediate the intervention-induced reduction in perceived stress levels. However, both factors significantly mediated a reduction in

perceived stress when they were tested individually in separate single mediator models. These results are in line with Gard et al. (2012), who showed that mindfulness had a non-significant mediating effect when it was tested simultaneously alongside self-compassion in a multiple mediator model, but a significant mediating effect (along with self-compassion) when tested in a single mediator model. A possible explanation for these results is that the correlation between the tested mediators probably compromised, at least to some degree, the effect of each mediator in the multiple mediator model. Another possible explanation is that since the recruitment specifically asked for highly stressed participants, stress reduction that was observed in both groups (although stronger effect found in the intervention group) after the 5-week period may be due in part to a regression to the mean effect. That is, stress levels might have been reduced to more normal levels for reasons which may not fully depend on the intervention.

Last, in terms of perceptions of well-being, the yoga intervention significantly contributed to increased levels of life

satisfaction but did not significantly improve participants' sense of harmony in life. This is perhaps because life satisfaction reflects a state construct, whereas harmony in life is more trait-like. It is possible that a longer intervention period is needed to make significant changes in trait-like and global evaluations.

Limitations and Future Research

Although this study utilized a rigorous experimental design with a control group and pre- and post-measurements, there is always a risk for placebo effects in this type of research. In other words, it is possible that the experimental effects observed (i.e., the positive coping and health effects of yoga) were in part caused by the participants expecting to improve as a result of the yoga intervention. We therefore recommend that future research replicates the study design while also including an active placebo group. Although it is difficult to conceive of a believable and ethical placebo manipulation, yoga research has occasionally employed watching videos or dancing as placebo conditions (see Riley and Park 2015 for a review).

Also, our study included only two time points that, to some extent, attenuate the mediation analyses since studies of mediation ideally require at least three measurements of the variables. Furthermore, the effects of the intervention on anxiety and sleep problems were only partially mediated by the two mediators. This suggests that mediators not measured in this study should be included in the model. Future studies could incorporate a longitudinal study of yoga, mindfulness, and stress, with other potential mediating factors included in the model. One could also test for potential moderating effects on the direct and indirect effects observed in this study. Potentially, the strong positive effects of yoga are limited to those who are highly motivated to try yoga. The effects may be smaller for those who are less motivated.

Although our study is promising in showing how a yoga intervention can benefit health, through incorporating yogic breathing as stress coping and related increases in mindfulness, more research is needed to determine the underlying mediating processes more precisely. It could potentially include both physiological and psychological components. Speaking for a potential direct physiological link between yogic breathing and relaxation are previous findings that taking long calm breaths reduces physiological arousal (Brown and Gerbarg 2009; Gilbert 1999; Grilley 2002; Sovik 2000), and the ablation of Cdh9/Dbx1 preBötzing complex neurons in mice lowered respiratory rates which, in turn, was accompanied by calm behaviors (Yackle et al. 2017). Also, previous research has found that yoga regulates the sympathetic nervous system and hypothalamic-pituitary-adrenal system, and minimization of inflammatory responses (Kiecolt-Glaser et al. 2010; Pascoe and Bauer 2015; Pascoe et al. 2017), which future research may test if it relates to yogic breathing.

The underlying processes may also be partly psychological. Our finding that increased yogic breathing was related to an

increase in participants' overall level of mindfulness could imply that participants began allowing themselves to perceive and endure the stressors as they are, without avoidance, judgment, or self-criticism, and allow for more deliberate stress coping than impulsive reactions (Baer et al. 2006; Gunaratana 2011). We encourage future research to test for underlying physiological and psychological processes, linking yogic breathing as stress coping to improved mental health. Future studies could, for example, induce acute stress in yoga practitioners, test for increases in yogic breathing (as compared to controls), and investigate physiological and psychological changes. It could be helpful to include also more objective measures (i.e., biomarkers of, e.g., physiological arousal, or brain imaging) to allow for examination of the possible biological mechanisms. We only used self-reported data in this study, which means that the risk for shared-method variance, conscious distortion, social comparison, and situational and contextual factors limits the conclusions.

Una Tellhed and Daiva Daukantaitė contributed equally to this work.

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Author Contributions UT created the study's main hypothesis and the YBSC scale, collaborated in the study design and execution, outlined the article, and collaborated in the writing of the article. DD was the project leader, led the overall study design and execution, analyzed the data, and wrote the results and the methods section. RM initiated the larger project within which the study was conducted and collaborated on design and writing. TS collaborated in results analysis and writing. OM financed the project and collaborated in design and writing. All authors approved the final version of the manuscript for submission.

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Compliance with Ethical Standards The study was approved by the Regional Ethical Review Board at Lund University in 2015 (Dnr 2015/610). Informed consent was obtained, and the participants were informed that their participation was voluntary and they could discontinue anytime without giving a reason and without penalty. Each participant was assigned an individual research code, which was used throughout the study to preserve participants' confidentiality. Each code was connected to the participant names only on a single master list kept in a safe and destroyed after data collection. Each study participant received a yoga mat.

Conflict of Interest The authors declare that they have no conflict of interest.

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