

# Exploring the effects of yoga for generalised anxiety disorder, with or without comorbidity

*A systematic review of randomised and non-  
randomised controlled trials*

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# Abstract

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**Title:** Exploring the effects of yoga for generalised anxiety disorder (GAD), with or without comorbidity: A systematic review of randomised and non-randomised controlled trials.

**Background:** Yoga is a philosophical system and a spiritual practice originating from a five-thousand-year-old Eastern discipline and is recommended as a therapy for a variety of medical conditions. Given the high prevalence of GAD and the deleterious consequences it has on the patient, effective treatments are considered crucial.

**Objective:** To systematically assess and meta-analyse the effects of yoga interventions in reducing anxiety in patients with GAD.

**Research question:** How may yoga alleviate anxiety amongst patients with GAD, with or without comorbidities?

**Methods:** A comprehensive systematic literature search was completed using search engine databases, including MedLine® ovid and PsycINFO® ovid during a period from September 2019 to April 2020. Risk of bias was assessed using adapted versions of the Cochrane Collaboration tools. A meta-analysis was conducted using the random-effect model to obtain standardised mean differences with 95 % confidence intervals.

**Results:** Of 565 studies identified through the literature search, four studies met inclusion criteria ( $N = 704$ ). All studies were assessed at serious risk of bias. Except for one study (Chad-Friedman et al., 2019), all reported significant results favouring the yoga intervention. A meta-analysis revealed evidence for large short-term effects of yoga on anxiety compared with treatment-as-usual and wait-list control ( $SMD = -0.92$ , 95 %  $CI = -1.28, -0.56$ ,  $p < 0.001$ ). Results suggest that yoga reduces anxiety symptoms for GAD patients.

**Conclusion:** The limited number of included studies and their low methodological quality prevents any firm conclusions from being drawn. High-quality studies are required to determine the effect of yoga on GAD.

**Keywords:** yoga, generalised anxiety disorder, anxiety, mental health, systematic review

# Preface

As a certified ashtanga, vinyasa and yoga therapy teacher, and aspiring clinical psychologist, I find therapies focusing on the interconnectedness of the mind and body to be particularly interesting. I am eager to understand more, and dive into the field of yoga research, and combine it with my clinical background. In addition to completing a master programme in health, developmental and societal psychology, I am concurrently studying for a clinical psychology master in Denmark. I believe that one of the most important arguments for the implementation of yoga in clinical settings is related to findings in the physiological mechanisms of yoga. Thus, non-secular aspects of yoga were not emphasised in this master thesis.

# Acknowledgements

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# 1 Introduction

Yoga is a philosophical system and a spiritual practice that originates from a five-thousand-year-old Ayurveda discipline that is practiced in various forms around the world (Hewitt, 1977). Originally considered to be a method of enabling spiritual awakening, yoga has become a popular form of physical exercise for stress-regulation and a recommended therapy for a variety of medical conditions (e.g. Mason & White, 2018; Yang, 2007; Gard, Noggle, Park, Vago, & Wilson, 2014). This master thesis provides a systematic review exploring the effects of yoga interventions for alleviating anxiety symptoms among adults diagnosed with generalised anxiety disorder (GAD), with or without comorbidity.

The evaluation is structured to introduce the background and rationale for conducting the review, including a more detailed consideration of both GAD and yoga (Chapter 1). Potential benefits of yoga on anxiety are examined, followed by a consideration of yoga's effectiveness on anxiety from earlier research (Chapter 2). The methodology and results of this systematic review are presented in Chapter 3 and Chapter 4 respectively. The results are discussed in various contexts including the challenges associated with the included studies, the strengths and limitations of this systematic review, the wider implications of this analysis, as well as future directions for further evaluation (Chapter 5). Finally, a summary and conclusion are formulated in Chapter 6.

## 1.1 Background

Anxiety is a mental and physical condition that is common to all human beings and associated with initiating protective and defensive behaviour (Mason & Gerbarg, 2018). When under potential life-threatening situations, the human body evokes a set of neuroendocrine responses which activate various stress-response systems preparing for survival (Tsatsoulis & Fountoulakis, 2006). These bio-physiological instincts have evolved as helpful emotions and can be considered as both highly adaptive and protective survival systems ('fight' or 'flight' responses). As such, anxiety is the body and mind's response to a dangerous, stressful, and unfamiliar situation, helping an individual to notice, avoid, or escape potential dangers (Gerbarg & Mason, 2018). From an evolutionary perspective fear and anxiety are considered advantageous and serve an adaptive function (Borkovec, Alcaine, & Behar, 2004). However, long-term overactivation of physiological systems in response to perceived threats in our

everyday life, or dysregulation and slow recovery of the stress response, are also associated with abnormally high levels of stress hormones and inflammatory markers. These, in turn, result in negative health consequences (Chrousos, 2009), especially when chronic stress levels have been reached (Streeter, Gerbarg, Saper, Ciraulo, & Brown, 2012), and may subsequently lead to a variety of medical conditions, including chronic anxiety disorders.

If cancer is “the emperor of all maladies” (Mukherjee, 2010, p. 1), anxiety disorders may be considered ‘the empress’ as one of the most prevalent mental disorders, affecting 33.7 % of the population during a lifetime (Bandelow & Michaelis, 2015). GAD is one of the most widespread anxiety disorders, with a one-year prevalence rate ranging from 3-8 % in primary care patients (Kessler et al., 2005; Wittchen et al., 2002). Characterised by pervasive, persistent, uncontrollable worry and tension (Allgulander, 2006), GAD impacts physical and mental health (Kirkwood, Rampes, Tuffrey, Richardson, & Pilkington, 2005; Doria, De Vuono, Sanlorenzo, Irtelli, & Mencacci, 2015), imposes significant personal distress, potential economic burden and reduced quality of life (Hoffman, Dukes, & Wittchen, 2008; Newman, Crits-Christoph, & Szkodny, 2013). Impairments may include social, occupational, physical, neurological and psychological processes (e.g. Wittchen, 2002) with increased risks of other psychiatric disorders, medical conditions and/or substance abuse (Kroenke, Spitzer, Williams, Monahan, & Lowe, 2007; Noyes, 2001). Despite the prevalence of GAD, and its consequential deleterious effects on health and functioning, it is frequently misdiagnosed or underdiagnosed (Vermani, Marcus, & Katzman, 2011), managed incorrectly (Wittchen, 2002), under-treated or treated with poor results; regardless of empirically supported treatments such as cognitive behavioural therapy (CBT; Gabriel, Curtiss, Hofmann, & Khalsa, 2018; Martín-Merino, Ruigómez, Wallander, Johansson, & García-Rodríguez, 2010; Kroenke et al., 2007; Weisberg, Dyck, Culpepper, & Keller, 2007).

Recent research has evaluated alternative therapies, including the ancient Eastern practice of yoga, as complementary treatments in an integrative approach to reducing anxiety (e.g. Woodyard, 2011; Cramer et al., 2018; Field, 2016). Yoga has gained recognition as a safe and effective therapeutic treatment, with evidence supporting potentially positive results for ameliorating anxiety (e.g. Zoogman, Goldberg, Voutsour, Diamon, & Miller, 2019; Javnbakht, Kenari, & Ghasemi, 2009). Regular yoga practice improves physical flexibility, cognitive functioning, emotional well-being, spinal mobility and muscle endurance (Field, 2016). Furthermore, when utilised as an alternative therapy, yoga may facilitate the development of relaxation responses which counteract anxiety, while encouraging meta-

cognitive modes of thinking which can potentially alleviate the negative effects of anxiety (e.g. de Manincor et al., 2016).

Compared with other forms of exercise, including metabolically matched exercise interventions, yoga is associated with greater relief from anxiety (Berger & Owen, 1988; Streeter et al., 2010). Whereas typical exercise is oriented externally, using extensive verbal and visual body language cues (Gard et al., 2014), yoga can foster internalised experiences of physical activity (Smith, Greer, Sheets, & Watson, 2011) and has been hypothesised to improve mental health symptoms by reducing the physiological impact of stress (Streeter et al., 2012). Evidence suggests that despite high-stress circumstances, people practicing yoga experience less anxiety. For example, cancer patients (e.g. Lundt, & Jentschke, 2019; Lin, Hu, Chang, Lin, & Tsauo, 2011; Pan, Yang, Wang, Zhang, & Liang, 2015), incarcerated individuals (e.g. Harner, Hanlon, & Garfinkel, 2010), pregnant women (Marc et al., 2011), individuals diagnosed with schizophrenia (e.g. Vancampfort et al., 2012), post-traumatic stress disorder tsunami survivors (Descilo et al., 2010) and others (see Field, 2011, 2016 for an overview of yoga research). Therefore, it is considered valuable to evaluate the benefits of yoga for individuals with GAD.

### **1.1.1 Selected review methodology**

Systematic literature reviews provide “access to high quality, relevant, accessible and up-to-date information” (Lasserson, Thomas, & Higgins, 2019, p. 3) to health care practitioners and policy makers, by summarising the best available research evidence regarding a specific health care intervention (Robertson et al., 2014). A systematic review is a rigid research method which identifies, assesses and compares information systematically, in order to track and gain comprehensive knowledge of previous research in a defined field, and identify potential gaps in knowledge (Aveyard, 2014). The review “attempts to collate all the empirical evidence that fits pre-specified eligibility criteria in order to answer a specific research question” (Lasserson et al., 2019, p. 4) and is considered as an essential tool for summarising evidence accurately and reliably (Liberati et al., 2009).

To our knowledge, no systematic review has exclusively explored the potential benefits of practicing yoga for the treatment of patients clinically diagnosed with GAD. Thus, the rationale for conducting an updated systematic review evaluating evidence to support yoga’s efficacy to alleviate the symptoms of GAD is considered appropriate. This master thesis provides a comprehensive systematic literature review of research into yoga treatment

for GAD, including neurobiological and cognitive (as well as affective mechanisms) likely to mediate the beneficial effects of yoga.

### **1.1.2 Rationale and research question**

Individuals with GAD are absorbed in uncontrollable worry of hypothetical scenarios causing physical and psychological distress (American Psychiatric Association, 2013). Developing the skills required to maintain flexible attention and mental equilibrium are essential in the treatment of GAD (Mason & White, 2018). The purpose of this systematic review is to enhance understanding and systematically explore the clinical effectiveness of yoga interventions as a potential treatment for GAD. Performing such a review will enhance and extend knowledge of GAD treatments and provide a deepened understanding of contemporary yoga therapy in the context of treating patients with GAD. For the purpose of this evaluation, the research question is:

*How may yoga alleviate anxiety amongst patients with generalised anxiety disorder (GAD) with or without comorbidities?*

This master thesis intends to elucidate this research question based on recent research, psychological theory and empiricism on the effects of yoga for people diagnosed with GAD.

## **1.2 Generalised anxiety disorder (GAD)**

Being anxious and worrying are mental and physical experiences common to all human beings that initiate protective and defensive behaviour to manage challenging future events (Gerbarg & Mason, 2018; Newman et al., 2013). GAD is clearly distinguishable from non-pathological anxiety due to its pervasive and distressing characteristics, and significant interference with psychosocial functioning, persistent course and resistance to change (Brown, Barlow, & Liebowitz, 1994; American Psychiatric Association, 2013). As an important context to this evaluation, the following sections of this chapter will explore psychological theory and empiricism of GAD in relation to typical symptoms and neurophysiology, etiology, epidemiology, diagnosis and treatment.

### 1.2.1 Typical symptoms of GAD

Worry is considered to be the cardinal feature of GAD and is defined as “a chain of thoughts and images, negatively affect-laden and relatively uncontrollable [...] attempt to engage in mental problem-solving on an issue whose outcome is uncertain but contains the possibility of one or more negative outcomes[...] [and] relate[d] closely to the fear process” (Borkovec, Robinson, Pruzinsky, & DePree, 1983, p. 10). As demonstrated in both anxious and non-anxious samples, worry is a negative cognitive activity often involving thought patterns about fearful future events (Borkovec & Inz, 1990; Borkovec, Ray, & Stober, 1998). In contrast to non-anxious samples, the worry (or physical symptoms associated with worry), cause clinically significant distress and the person finds the worry intrusive and difficult to control (American Psychiatric Association, 2013; Holmes & Newman, 2006).

Individuals with GAD often experience worry as a persistent activity which develops into a disabling source of intense emotional discomfort (Newman et al., 2013). Whereas worry may relate to significant life challenges, individuals with GAD experience the insignificant day-to-day issues to be greatly exaggerated in relation to the real threat exposure. According to Borkovec et al.’s cognitive avoidance theory of worry (e.g. Borkovec & Roemer, 1995; Borkovec et al., 2004), the overreliance on the cognitive control strategy of worry may function as an avoidance mechanism, motivated by the need to manage affective reactivity or negative emotional arousal (e.g. Borkovec et al., 2004). As such, worry is employed as a coping behaviour to avoid negative emotional activation, allowing individuals to avoid distressing internal experiences (Borkovec & Hu, 1990; Llera & Newman, 2010; Newman & Llera, 2011). Compared with non-anxious individuals, patients with GAD consider the highest perceived function of worry to be a “distraction from more emotional topics” (Borkovec & Roemer, 1995, p. 26) as they “prefer to feel chronically distressed in order to prepare for the worst outcome” (Newman & Llera 2011, p. 375).

Individuals with GAD often experience fear as a key symptom and persistently scan their environment for social threat cues, thus exhibiting hypervigilance towards threat, with a tendency to negatively interpret ambiguous or neutral stimuli (e.g., Mathews & MacLeod, 1985; Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Ijzendoorn, 2007). An increasing variety of stimuli are therefore considered as threatening (Hettema, Prescott, Myers, Neale, & Kendler, 2005). Furthermore, patients with GAD often engage in the psychological construct known as the ‘intolerance of uncertainty’ which is characterised as an inclination to respond negatively to uncertain situations and with a disposition to overestimate

the anticipated likelihood of negative implications (Gentes & Ruscio, 2011; Borkovec et al., 1998; Buhr & Dugas, 2009; Boswell, Thompson-Hollands, Farchione, & Barlow, 2013).

Utilisation of worry to avoid emotional processing of aversive stimuli may self-maintain and negatively reinforce the GAD condition and disrupt any potentially beneficial effects when exposed to fear (Newman et al., 2013; Mennin, Heimberg, Turk, & Fresco, 2005; Stapinski, Abbott, & Rapee, 2010).

Additionally, GAD is associated with an absence of present-moment focus of attention by reacting to, and avoiding such uncomfortable internal experiences (Hoge et al., 2018; Roemer, Orsillo, & Salters-Pedneault, 2008; Roemer et al., 2009). By continually creating and allocating attention to negative situations arising from non-existent future illusions, a person with GAD can disconnect from the present ‘here and now’. According to Borkovec et al. (2004), this characteristic of GAD is in most need of treatment.

GAD patients, especially those in primary care settings, typically present their symptoms through non-specific somatic symptoms such as headaches, gastrointestinal distress, back pain and insomnia (Bolton et al., 2006a; American Psychiatric Association, 2013; Stein & Sareen, 2015). Individuals with GAD are often associated with rapid chest breathing (usually shallow breathing, inhaling minimal breath into the lungs) which in turn activates the sympathetic response. Reciprocally, sympathetic activity reinforces rapid breathing (Mason & Gerbarg, 2018).

### **1.2.2 Psychophysiological characteristics of GAD**

GAD has a complex psychophysiological characterisation, influencing the cardiovascular, gastrointestinal, endocrine, respiratory and immune systems, all of which are regulated by interactive feedback loops within the nervous and circulatory systems. Specifically, GAD has been associated with dysfunctions in the autonomic nervous system (ANS). The ANS includes the parasympathetic nervous system (PNS), responsible for the body’s rest and digestion responses when the body is resting, relaxing or feeding (Freedman, Greis, Marino, Sinha, & Henstenburg, 2014), and the sympathetic nervous system (SNS), which governs the ‘fight-or-flight’ response, mobilising energy for action (McCorry, 2007). These two systems are coordinated, enabling individuals to react to changing external and internal stimuli that counterbalance each other, with the PNS colloquially functioning as the “yin” to the SNS “yang” (Gordon & Fleisher, 2011, p. 20). The following section considers details concerning the psychophysiological characteristics relating to GAD including autonomic

inflexibility/dysregulation, low cardiac vagal tone and dysfunction in emotion regulatory circuits.

The human body invokes a set of neuroendocrine responses when reacting to external or internal stressors. The responses activate various stress-response systems, including the ANS and Hypothalamic–pituitary–adrenal (HPA) axis, resulting in increased secretion of glucocorticoids and catecholamines (Tsatsoulis & Fountoulakis, 2006). Individuals with GAD are vulnerable to elevated stress reactivity in relation to threatening stimuli and may find it difficult to recover from a triggering event (Mason & Gerbarg, 2018; Bar-Haim et al., 2007). This hinders the individual to adequately respond to constantly changing environments (Forcier et al., 2006). Consequently, the HPA axis results in the secretion of the hormone cortisol, a glucocorticoid that mobilises stored energy and increases cardiovascular and respiratory activity (Sapolsky, 1992). The inability to disengage from threat is associated with heightened activity of the SNS, underpinned by chronic underactivity of the PNS, resulting in imbalances in the ANS (Chalmers, Quintana, Abbott, & Kemp 2014). The associated autonomic inflexibility can induce increased release of the catecholamine excitatory neurotransmitters norepinephrine and epinephrine, which consequently leads to faster breathing and increased levels of physiological functions, such as arousal, alertness, vigilance, heart rate and respiratory rate (Thayer, Friedman, & Borkovec, 1996). These physiological reactions are subjectively experienced as unpleasant (Buchanan, al'Absi, & Lovallo, 1999).

Evidence suggests that excessive worry is associated with physiological dysfunction, particularly cardiovascular activation (e.g. Llera & Newman, 2010; Stapinski et al., 2010). Correspondingly, chronic worry can lead to autonomic inflexibility as a result of low cardiac vagal tone, which represents the contribution of vagus nerve activation (the main parasympathetic nerve) to cardiac regulation (e.g. Porges, 2001; Hofman, Moscovitch, Litz, Kim, Davis, & Pizzagalli, 2005; Hofmann, Schulz, Heering, Muench, & Bufka, 2010). In contrast to other anxiety disorders, patients with GAD typically show a reduction in the heart rate variability (HRV) in response to threat, a measure of the beat-by-beat variation in heart rate over time (influenced by sympathetic nerve fibres and the vagus nerve; Newman et al., 2013; Thayer et al., 1996). For example, in an examination of HRV during rest, negative imagery and worry-induced thinking, states of worry were activated among GAD patients, which create a reduction in vagal tone (Llera & Newman, 2010; Lyonfields, Borkovec, & Thayer, 1995).

High frequency HRV output is attributed to vagal activity, while low frequency HRV is attributed to sympathetic output (Shaffer & Ginsberg, 2017; Chalmers et al., 2014). Additionally, higher HRV indicates that the heart can adapt to variations in environmental stimuli more rapidly and is generally considered a more adaptive physiological response to stress (Dishman et al., 2000). Therefore, research suggests that individuals with GAD may have chronically low vagal tone, characterised by a low HRV and a high, stable heart rate and the inability of the vagus nerve to convey sensory information concerning the body's organs to the central nervous system (CNS; Thayer et al., 1996; Newman et al., 2013; Brosschot, 2010; Brosschot & Thayer, 2003; Hoehn-Saric, McLeod, Funderburk, & Kowalski, 2004; Lyonfields et al., 1995). Similarly, empirical findings suggest that the vagal deficiency and associated autonomic inflexibility found in patients with GAD are related to pervasive worry, whereas autonomic flexibility demonstrates resilience and the ability to achieve homeostasis, despite exposure to environmental challenges (Tyagi, Cohen, Reece, Telles, & Jones, 2016).

Functional neuroimaging studies have suggested that GAD is associated with dysfunction in the emotion regulatory circuits (Stein & Sareen, 2015; Robinson et al., 2014; Hilbert, Lueken, & Beesdo-Baum, 2014; Ball, Ramsawh, Campbell-Sills, Paulus, & Stein, 2013). The medial prefrontal cortex (mPFC), balances the activity in the lower subcortical centres, particularly the amygdala, via multiple routes, including the thalamus (Mason & Gerbarg, 2018). The amygdala is the centre of various defensive reactions, including the induction of fear response to external stimuli (Feinstein, Adolphs, Damasio, & Tranel, 2011). Studies display hyperactive amygdala responses to fear stimuli in patients with GAD (e.g. Fonzo et al., 2015; Etkin, Prater, Hoeft, Menon, & Schatzberg, 2010; Etkin & Schatzberg, 2011; Butler et al., 2007). When the amygdala is overactive the mPFC acts as an inhibitory system. However, chronic stress appears to reduce gray matter volume in the mPFC (Simpson, et al., 2001; Radley et al., 2004), thereby reducing mPFC activation (Craske et al., 2017; Etkin & Wager, 2007). These brain circuits are functionally connected with the thalamus which communicates with the amygdala, mPFC, and cerebral cortex. Simply put, the thalamus encodes threatening information and sends this input to the amygdala. If insufficiently inhibited by the mPFC, the amygdala then triggers a fear response by activating various brain circuits, as well as the SNS and the HPA axis. Similarly, threatening thoughts may activate the mPFC, thereby sending input to the amygdala, stimulating an integrated inherent response via the thalamus, resulting in physical symptoms of anxiety (Immordino-

Yang & Yang, 2017 as cited in Mason & Gerbarg, 2018; Etkin, 2009; Canteras, Resstel, Bertoglio, de Pádua Carobrez, & Guimaraes, 2009).

Gamma-aminobutyric acid (GABA) is the primary inhibitory neurotransmitter implicated in this pathology, as it is essential for emotion regulation (Mason & Gerbarg, 2018; Streeter et al., 2012; Möhler, 2012). Neurons in the prefrontal cortex (PFC, in addition to other cortical structures and the thalamus) release GABA, which has a primary task of inhibiting overactivity in the amygdala (Friedman, 2007). GABA inhibits over-reactivity by attaching to receptor sites in the amygdala, thereby reducing anxiety reactions (Mason & Gerbarg, 2018). Research suggests that individuals suffering from GAD have lower levels of GABA and that other biochemicals associated with anxiety may block GABA receptor sites (Nuss, 2015; Streeter et al., 2010).

### **1.2.3 Epidemiology**

Epidemiological factors have been found to contribute to the development of GAD and will be briefly explored in the following section as important contexts in this evaluation. Many individuals with GAD report that they have felt anxious their whole life (American Psychiatric Association, 2013). The median age of onset is 31 years (Newman et al., 2013), but the age at onset is spread over a wide range (Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012). The highest rate of GAD occurs in individuals between 45-49 years (7.7 %) and the lowest rate occurs in individuals 60 years or older (3.6 %; Kessler et al., 2005). The prevalence is approximately twice as high among women (55-60 %) compared with men (American Psychiatric Association, 2013; Kessler & Wang, 2008; Grant et al., 2005; Kavan, Elsassner, Barone, 2009), and over time the prevalence decreases with age for men whereas it increases for women (Halbreich, 2003, as cited in Kavan et al., 2009). GAD is more frequent in Caucasians, when compared to other groups such as individuals of non-European descent, including Asian, African and Native American (e.g. Asnaani, Richey, Dimaite, Hinton, & Hofmann, 2010). There is a higher frequency of reporting the symptoms of GAD in developed countries than that of under-developed countries (Lee et al., 2009; Stein, Scott, de Jonge, & Kessler, 2017). Furthermore, GAD is chronic and fluctuates between syndromal and sub-syndromal symptoms of the disorder (Angst, Gamma, Baldwin, Ajdacic-Gross, Rössler, 2009). Full remission rates are considered low (Bruce et al., 2005) and relapse rates are high (Brawman-Mintzer & Lydiard, 1996 as cited in Doria et al., 2015).

### **1.2.4 Etiology**

Multifaceted etiological factors have been attributed to the development of GAD, including a complex interrelated contribution of genetic, environmental, biological and psychological vulnerability aspects (Newman et al., 2013). This section briefly explores the developmental vulnerabilities and interpersonal processes as important contextual factors (for example in diagnosing GAD) in this evaluation. Research featuring the genetic determinants of anxiety disorders, such as twin studies, have found a genetic disposition estimated between 15-20 % (Hettema et al., 2005). Personality traits related to temperament, including negative affectivity and neuroticism (Kessler et al., 2008) have been associated with the development of GAD, accounting for 30-50 % of the variance (Newman et al., 2013). Gender is also an influential genetic risk factor, with females being more likely than men to develop an anxiety disorder (McLean, Asnaani, Litz, & Hofmann, 2011; Moreno-Peral et al., 2014). Furthermore, research has found that a parental history of anxiety and mood disorders, such as GAD (Beesdo et al., 2010), depression (Lieb, Isensee, Höfler, Pfister, & Wittchen, 2002) or other mental health problems (Kessler & Wang, 2008) can double, or even quadruple, the likelihood of their children developing GAD. It is notable that some of these hereditary predispositions may be difficult to distinguish from environmental risk factors, including the care provided (e.g. poor nutrition), exposure to childhood adversity (e.g. physical or sexual abuse) and parental overprotection (Antony & Stein, 2009; Moreno-Peral et al., 2014).

### **1.2.5 GAD diagnosis**

The intensity and frequency of GAD varies across individuals, however the key feature for the conceptualisation of the diagnosis is worry (American Psychiatric Association, 2013). Defined by the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) criteria (as shown in Appendix A), GAD is characterised by excessive and uncontrollable multifocal worry that has been present for at least six months and that is often focused on potential future threats, or other events and activities/situations (such as family, health, work and finances).

The worry (and associated anxiety) is typically combined with three or more of the following symptoms: restlessness, being easily fatigued, irritability, muscle tension, sleep disruption or challenges in concentration (American Psychiatric Association, 2013). A differentiation is made between state and trait anxiety. State anxiety reflects a temporary

condition characterised by psychological and physiological transient responses related to a perceived threat in a specific moment. Trait anxiety refers to a personality trait that has deleterious effects on health over time (Spielberger, 2010). Prolonged and frequent anxiety responses may also increase anxiety intensity and the size of the perceived threat. As the anxiety level becomes more dysfunctional it may meet the criteria defining an anxiety disorder (Mason & Gerbarg, 2018).

A physician may diagnose GAD by utilising screening tools such as Generalized Anxiety Disorder 7-item scale (GAD-7) to assess the presence and severity of symptoms (Spitzer, Kroenke, Williams, & Löwe, 2006). Screening tools may detect a probable diagnosis and should be followed by more extensive interviews using the DSM criteria, for example the structured clinical interview for the DSM-5, together with suitable management and referral (Kavan et al., 2009).

The GAD diagnosis is further complicated with high rates of comorbidity (45-91 %) with psychiatric and medical conditions. This includes other anxiety disorders, major depression (Katzman et al., 2014; Bystritsky, Khalsa, Cameron, & Schiffman, 2013; Comer et al., 2011; Kroenke et al., 2007; Wittchen, Zhao, Kessler, & Eaton, 1994), and the risk of cardiovascular, gastrointestinal and respiratory disease conditions (Martens et al., 2010; Wittchen et al., 2002), pain syndromes (Comer et al., 2011; Beesdo et al., 2009) and hypertension (Comer et al., 2011). Judd et al. (1998) reported that 80 % of subjects with a lifetime diagnosis of GAD also had a lifetime mood disorder diagnosis, and Grant et al. (2005) reported that only 10.2 % of participants did not have a comorbid mental disorder. Substance abuse (Wittchen et al., 1994; Wittchen, Perkonig, & Reed, 1996), personality disorders (Grant et al., 2005; Johnson, Roth, & Breslau, 2006), bipolar disorder (Grant et al., 2005), sleep disturbance (Batterham, Glozier, & Christensen, 2012), and depression (Kendler, 1996) constitute other important categories of comorbidity that may complicate the natural history of the anxiety disorders (e.g., Massion, Warshaw, & Keller, 1993; Noyes, 2001). Additionally, studies suggest that gender can influence consequences of comorbidity where comorbidity in females is typically linked to anxiety disorders and unipolar depression, whereas it is more likely to also include substance abuse in males (Kramer & Wang, 2008; Vesga-López et al., 2008).

Due to these high levels of comorbidity with other mental health disorders and medical issues, clinical assessments must consider whether GAD is better explained with another disorder, while taking differential diagnosis into consideration.

### 1.2.6 Standard treatment

The standard treatment for patients with GAD is currently CBT and pharmacotherapy (Katzman et al., 2014). CBT is a form of psychological treatment addressing several core principles, including psychological issues based on faulty or unhelpful thoughts, feelings, behaviour and associated bodily sensations. CBT assists individuals suffering from psychological problems by enabling improved coping mechanisms, symptom relief and improved quality of life. Treatment typically involves focused models promoting changes in an individual's way of thinking and behavioural patterns (Fenn & Byrne, 2013). It is prominent in empirically supported treatments (ESTs) and is considered a well-researched and well-established form of psychotherapy (David, Cristea, & Hofmann, 2018; Stewart & Chambless, 2009). In contrast to CBT, pharmacological treatments, such as selective serotonin reuptake inhibitor, and serotonin-norepinephrine reuptake inhibitor, target the biochemical principles underlying the anxiety (Hofmann, Sawyer, Korte, & Smits, 2009).

Research confirms that CBT is highly effective in decreasing anxiety and GAD symptoms, with improvements maintained for up to two years following treatment termination (e.g. Covin, Ouimet, Seeds, & Dozois, 2008; Borkovec & Ruscio, 2001). The value of CBT in real-life clinical trials for anxiety disorders is considered robust (Stewart & Chambless, 2009) and is also associated with a reduced requirement for anxiolytic medication (Newman et al., 2013). However, there is controversy about the efficacy of CBT outside clinical trials (Manson & Gerbarg, 2018). A treatment-satisfaction survey for CBT and pharmacotherapy found that only 41.4 % of the patients with anxiety disorders felt they received quality assistance, and only 44.8 % of the patients were satisfied with the mental health care they received (Stein et al., 2011). Additionally, CBT has been claimed to be a sub-optimal treatment for individuals with GAD (Hofmann & Smits, 2008; Ninan, 2001) and GAD patients have demonstrated a poor response to psychotherapy when compared with other anxiety disorders (Brown, Barlow, & Liebowitz, 1994).

Although several studies have documented the clinical effectiveness of pharmacology for GAD, many patients continue to be symptomatic (e.g. Yonkers, Bruce, Dyck, & Keller, 2003) and patients continue to express a substantial number of residual symptoms during and after treatment. Satisfaction responses to short-term selective serotonin reuptake inhibitors and serotonin-norepinephrine reuptake inhibitors for the treatment of GAD occurs in approximately 60 % of patients (Newman et al., 2013). Concerns about the potential side effects, high costs of treatment, potential addiction to medication and dissatisfaction of these

pharmacological treatments may contribute to low treatment adoption and adherence (Zivin, Madden, Zhang, Soumerai, & Graves, 2009; Sajatovic et al., 2011). According to Bystritsky (2006), approximately 30 % of patients recover with standard pharmacology treatment, while another 30-40 % are considered improved. Additionally, the actual number of individuals suffering from GAD may be underestimated as many choose to self-manage the condition, rather than seek a medical opinion or accept psychological or pharmaceutical interventions (Morgan & Jorm, 2009). Others may rely on substances such as alcohol to alleviate their symptoms in the short-term (Stein & Sareen, 2015; Bolton, Cox, Clara, & Sareen, 2006b).

The aforementioned research emphasises the need to reconsider the medical management of patients suffering from GAD and evaluate new approaches treating this disorder. In this context, there has been growing interest in mind-body, and complementary and alternative medicine therapies (i.e. practices that consider the mind and body as non-dualistic such as yoga, mindfulness and qigong; Barrows & Jacobs, 2002) to alleviate anxiety symptoms (Barić, Đorđević, Cerovečki, & Trkulja, 2018). These therapies are based on natural remedies and are considered cost-effective, accessible, and as having a limited number of side effects (Büssing, Ostermann, Lüdtke, & Michalsen, 2012). This has led to an increasing interest in the potential role of yoga for treating anxiety symptoms among those diagnosed with anxiety disorders (e.g. Cramer et al., 2018; de Manincor et al., 2016). Yoga has been adopted both as a standalone anxiety treatment and as an adjunctive strategy to medication and/or psychotherapy (da Silva, Ravindran, & Ravindran, 2009).

### **1.2.7 Master thesis definition of GAD**

For the purpose of this investigation the definition of GAD is a pervasive form of anxiety provoked by worry and causing intense emotional discomfort. Since GAD diagnosis is further complicated by high rates of comorbidity, the research question also includes patients suffering from GAD, with or without comorbidities. Furthermore, for the purpose of analyses, it is of interest to evaluate state anxiety, as opposed to trait anxiety, in order to assess short-term changes in anxiety.

## 1.3 Yoga

The term yoga is derived from the Sanskrit definition ‘*yujir-yoge*’, meaning to unite, join or yoke. It is a spiritual practice based on ancient Eastern teachings with the intention of uniting the mind, body and spirit to achieve increased mental attention and awareness (Hewitt, 1977; Cook-Cottone, 2015). Yoga is commonly regarded as a physical health practice in Western contemporary settings. However, it is also considered as a broader and more comprehensive practice, with deeply philosophical and spiritual roots, and an overarching goal of liberating the self and realising an individual’s true potential (Cope, 2007). The following sections provide a brief background on yoga philosophy and history, together with a consideration of recent psychological theory and empiricism, as a framework for evaluating the potential beneficial effects of yoga in the context of GAD therapy.

### 1.3.1 Yoga philosophy

Yoga philosophy is one of the six major orthodox systems of Hindu philosophy (Jacobsen, 2017; Burley, 2000). According to archaeological evidence, yoga’s origin is thought to date back to pre-Vedic Indian traditions, presumably originating from the Indus Yoga Civilisation around 3000 BCE (Ray, 1995). However, the origins of the yoga school of Hinduism are unclear and elements of yoga philosophy can also be found in both Jainism and Buddhism (Simpkins & Simpkins, 2011; Stephens, 2010). Yoga scholars have identified several ancient texts that are believed to be the early foundations of today’s yoga (Stephens, 2010).

The first written synthesised organised knowledge of yoga was the yoga sutras (YS), an approximately two-thousand-year-old collection of 196 Sanskrit aphorisms on the practice and theory of classical yoga or Raja yoga. This work was compiled by the Indian sage Patanjali before 400 CE (believed to date from 325-425 CE; Feuerstein, 1989; Mæland & Larsen, 2016). The YS are often referred to as the “bible of yoga” (Devereux, 1979 as cited in Lyengar, 1979, p. 8) providing information regarding the development of the mind. This is considered essential to yoga philosophy as mental refinement is necessary for spiritual transformation, which in turn is part of the yogic path (Mason & White, 2018).

This spiritual transformation is expressed in the second sutra, “*Yoga citta vritti nirodhah*” translated to: “Yoga is the restriction of the fluctuations of consciousness” (Feuerstein, 1989, p. 26). Patanjali defined yoga as a restraint of consciousness or awareness (*citta*), consisting of three components; desiring or lowering the mind (*manas*), ego

(*ahamkara*) and intelligence (*buddhi*). Specifically, relevant in the context of anxiety disorders, the *vruttis* is considered as fluctuations of the mind that lead to mental agitation and confusion. The goal of yoga is to enable a gradual suppression or restriction (*nirodhah*) of such processes (*vruttis*; Mason & Gerbarg, 2018). Yoga philosophy considers the greatest stress to come from such fluctuations, for example, as it progresses towards future worries (Feuerstein, 1998; Borkovec et al., 1998).

In Patanjali's YS, yoga is classified as a multi-layered system for a morally disciplined and purposeful life, known as the eight limbs of yoga (*ashtanga yoga*). The two first limbs of the eightfold path comprise ethical behaviour, the abstinences (*yamas*) and observances (*niyamas*). Listed in the YS 2.30, the *yamas* are universal ethics or moral rules practiced individually, consisting of self-regulating behaviours that indicate how people should interact with other people, living beings and the environment; non-violence (*ahimsa*), truthfulness (*satya*), non-stealing (*asteya*), chastity (*brahmacharya*) and non-possessiveness (*aparigraha*). The *niyamas* are internal personal practices, or individual ethics, which encourage the personal growth. They include habits, behaviours and observances aimed to achieve purity (*sauca*), contentment (*santhosa*), self-discipline (*tapas*), self-study (*svadhyaya*) and commitment to the *Ishvara* – the God or supreme being (*ishvarapranidhana*). Together, the *yamas* and *niyamas* create positive perceptions and actions that lead to improved well-being (Mason & White, 2018; White, 2019; Iyengar, 1979).

The next two limbs include posture (*asana*) and breath control (*pranayama*) and are considered to enhance self-regulation by balancing the ANS, resulting in equilibrium and stillness of the mind (Mason & White, 2018). Conscious breathing in yoga enables the participant to navigate the different levels of consciousness. The fifth limb, withdrawal of the senses (*pratyahara*), is believed to help explore hidden facets of one's being. Through *pratyahara*, the practitioner learns not to adhere to thoughts in a mindful manner, potentially purifying the mind of unhelpful thoughts. When the first five limbs have been mastered, the practitioner moves to the more subtle, intimate, internal and subjective fulfilments of the yoga discipline. The sixth limb, concentration (*dharana*), is achieved by not allowing the mind to be disturbed by thoughts, sounds or emotions, for example by cultivating a specific object of focus. The seventh limb is a deep-rooted, profound, and abstract contemplative meditation (*dhyana*). Finally, the eighth limb, complete absorption (*samadhi*), is when all limbs are combined, and the practitioner achieves a state of oneness and self-realisation (Iyengar, 1979; White, 2019).

### 1.3.2 Modern yoga

The practice of modern yoga was introduced to the Western world from the 1930s to the 1970s. The most common practice of yoga in Western societies is *hatha* yoga, with an emphasis on movement, balance and stretching in physical postures (*asana*), while utilising awareness and control of the breath (*pranayama*) and engaging in meditation (*dhyana*) to cultivate mind-body connection and self-awareness (Hewitt, 1977; de Michelis, 2005). A typical yoga sequence and associated yoga styles are presented in Appendices B, C and D. Yoga has become an increasingly popular method of achieving well-being and improving physical and mental health. In the US, for example, approximately 13.2 % practice yoga with lifetime prevalence (Cramer, Lauche, Langhorst, & Dobos, 2016). Furthermore, the importance of a regular yoga practice has been emphasised in both the YS as well as empirically (e.g. Falsafi & Leopard, 2015; Mason & White, 2018). Additionally, even a single session of yoga has been shown to reduce anxiety symptoms (e.g. Newman et al., 2014).

### 1.3.3 Master thesis definition of yoga

For the purpose of this investigation, the definition of yoga incorporates multicomponent yoga interventions including yoga postures, breathing and relaxation. Patanjali's yoga system is often used as the model for considering yoga in contemporary research studies (Khalsa, 2016 as cited in Mason & White, 2018), and will be used as a principle in this systematic review. Research suggests that various styles of yoga can have a positive health contribution (e.g. Cramer et al., 2016), and therefore a broad definition of yoga styles will be utilised. Differentiation is made between bottom-up and top-down yoga mechanisms, however, it is important to note that there is a bidirectional interaction between the two.

## 2 How may yoga alleviate GAD?

Research published as early as 1971 found that practicing yoga improved symptoms of general anxiety and depression by 82.5 % (Deshmukh, 1971 as cited in Gabriel et al., 2018). There are many plausible mechanisms for yoga to impact anxiety, including physiological, psychological, and behavioural mechanisms (Uebelacker & Broughton, 2018; Sengupta, 2012). Yoga is proposed to have an effect on biological function and therefore reduce levels of anxiety and promote well-being through an integration of bottom-up and top-down processes, facilitating bidirectional communication between mind and body (Gard et al., 2014). Additionally, yoga is considered to regulate autonomic, neuroendocrine, emotional and behavioural activation and may have a positive influence on an individual's response to challenging situations (Taylor, Goehler, Galper, Innes, & Bourguignon, 2010; Muehsam et al., 2017). The following sections consider the theory and empiricism for the rationale to use yoga as a treatment for GAD. Available evidence will be examined to evaluate the effectiveness of bottom-up and top-down yoga mechanisms as an anxiety treatment regulating cognitive, emotional, behavioural and peripheral physiology. Focus is given to the potential physiological effects of yoga on the nervous and endocrine system (based on polyvagal theory), followed by a consideration of the positive effects of body awareness.

### 2.1 Polyvagal theory

The polyvagal theory, developed by Porges (e.g. 1995a, 1998, 2003, 2011) provides a brain-body model based on the bidirectional communication between the brain and body when mammals respond to threatening situations and environments. By combining evolutionary biology and neuroscience, the polyvagal theory posits that the vagus nerve, is interconnected with, sensitive to, and influenced by, the CNS. Additionally, the vagus nerve is characterised by a reactivity that adapts according to the phylogeny of the neural circuits and interacts with source nuclei in the brainstem (Porges, 2011). The theory provides important contributions and new perspectives to a wide range of psychiatric conditions by highlighting the phylogeny of the ANS (Porges, 2007, 2009).

Polyvagal theory emphasises three phylogenetic circuits in neural regulation of the ANS. The oldest circuit, the dorsal vagus complex, is an unmyelinated (i.e. nerve fibers that are not covered with a myelin sheath) integrative centre associated with responses to immense

danger. These responses include immobilisation and behavioural shutdown reactions that may be experienced by humans as a disembodied and dissociative state. The second developmental circuit, the SNS, can produce metabolic output and mobilisation behaviours necessary for ‘fight or flight’. The third and most advanced pathway, the ventral vagus complex is a newer (in evolutionary terms) mammalian vagal circuit. In contrast to the dorsal vagus complex, the ventral vagus complex is myelinated (i.e. nerve fibers are covered with a myelin sheath that expedites signalling transmission). It is also codified as the social engagement system, a cardinal feature of managing threat, by enabling calm states (thereby promoting growth, repair, and restoration) and is most accessible during states of safety (Porges, 2001). The myelinated vagal efferent fibers serve as a vagal brake by regulating activation and enabling control of heart rate. Increasing vagal tone reduces heart rate and blood pressure, whereas decreased vagal tone accelerates heart rate (Porges, 2003; Eide-Midsand & Nordanger, 2017). As described earlier, GAD is characterised by reduced autonomic flexibility that may reduce the capacity to adjust to environmental challenges (Weber et al. 2010) and is associated with low HRV (cardiac autonomic control) and vagal tone (Friedman, 2007).

## **2.2 Bottom-up mechanisms of yoga**

Yoga has potential to relieve symptoms of GAD by improving the physiological dysfunctions associated with the diagnosis (Mason & White, 2018). Bottom-up processes, such as breathing techniques and mindful movement, may affect the cardiovascular, musculoskeletal and nervous system. Yoga practitioners often experience the positive effects of bottom-up mechanisms, including reductions in psychological stress, enhanced immune function and improved mood (Taylor et al., 2010; Muehsam et al., 2017).

### **2.2.1 The potential effect of yoga on physiological dysfunctions in GAD patients**

Yoga breathing and movements enhance regulation of the ANS by manipulating and changing the phylogenetic circuits as defined in the polyvagal theory (Sullivan et al., 2018; Sovik, 2000; Porges, 2011). Yoga practices enable an individual to develop skills that require reflective engagement of the CNS while in action, as well as promoting calm states through deep breathing and mindful focused attention. For example, our brains and bodies interpret long and slow pulmonary ventilation as a sign of safety and security (Porges, 2011).

Additionally, yoga practices such as the advanced breathing exercise *kapalbhati pranayama* (fast diaphragmatic breathing) increase the respiration and heart rate (thereby activating the SNS and dorsal vagus complex branches of the ANS) and may be applied in yoga interventions to elicit observations of physiological reactions (such as the sensation of increased energy) in a safe and controlled environment. In this way, the GAD patients may become more comfortable in their own bodies and gain knowledge of how their bodies react to different stimuli. Yoga enables the practitioner to become aware of ANS bodily reactions by moving from a state of activation, defense or reaction to restoration and repair, which in turn strengthens vagal inhibition (Ogden, 2018; Cook-Cottone, 2015). The shift between movement and relaxation enhances the ability of the ANS to fluctuate from arousal to calm, meaning that practicing yoga promotes access to the reflective and relational areas of the nervous system, despite challenging or threatening situations (Porges, 2011).

Yoga practices are also considered to regulate the imbalances of the ANS by regulating the GABA-glutamate balance via stimulation of the vagus nerve (Mehta & Gangadhar, 2019). As described earlier, GAD indicates underactivity of GABA which facilitates amygdala activation generating and maintaining the fear response (Friedman, 2007; Nuss, 2015). Streeter et al. (2007, 2010) revealed that yoga practices increase GABA activity in the thalamus and promote GABAergic transmission along inhibitory pathways from the PFC and insular cortex to the amygdala. This process also decreases the overactivity of the amygdala associated with anxiety (Streeter et al., 2012; Mason & Gerbarg, 2018). As a result of these findings and polyvagal theory (e.g. Porges, 1995a), Streeter et al. (2012, 2018) proposed the vagal-GABA theory, suggesting that yoga practices can correct for the decreased PNS and GABAergic activity found in disorders exacerbated by stress, such as GAD.

One of the most notable physiological effects of practicing yoga is the facilitation of autonomic balance by the physiological response of increasing HRV. This is also associated with improved adaptation to changing environmental stimuli and physiological reactions to stress (Dishman et al., 2000; Tyagi & Cohen, 2016; Appelhans & Luecken, 2006) and enabling relaxation once the stressful situation has passed (Mason & White, 2018). Additionally, yoga is considered to increase ventral vagal tone, which has been associated with improved internal integration, emotional regulation, empathetic response and connectedness with others (Porges, 2011; Brown & Gerbarg, 2009; Mason & White, 2018).

Yoga's impact on HRV and vagal tone is primarily derived from physical postures (*asana*) and breathing techniques (*pranayama*) and their combined effects (Tyagi & Cohen,

2016). *Pranayama* practices that encourage increase in PNS activity include elongated exhalation and conscious, slow and gentle abdominal breathing, which in turn increases vagal transmission to the heart and reduces the heart rate (Mason & Gerbarg, 2018). For example, pauses after deep inhalation stimulate baroreceptors in the lungs, providing feedback to vagal nuclei and thereby promoting vagal tone (Porges, 1995b). As aforementioned, GAD patients tend to engage in shallow breathing. Therefore, learning new patterns of breathing, through yoga practice, can contribute to alleviating anxiety symptoms and cultivating resilience. Furthermore, physical yoga postures based on biomechanical changes in body position (e.g. heart-opening poses) can theoretically enhance pulmonary and cardiovascular function (Behrakis, Baydur, Jaeger, & Milic-Emili, 1983; Galanis et al., 2013). Additionally, yoga has been found to be effective in improving cardiac autonomic control in vulnerable samples (e.g. Yadav, Singh, Singh, & Pai, 2015; Santaella et al., 2011), although this has not always been found in healthy samples (e.g. Bertisch, Hamner, & Taylor, 2017).

As considered earlier, GAD is associated with increased secretion of cortisol produced via HPA-axis signalling. Research suggests that practising yoga enhances positive changes in this biochemical environment (Field, Diego, Delgado, & Medina, 2013; Riley & Park, 2015; Naveen et al., 2016) by activating bottom-up parasympathetic pathways through calming breathing techniques and body posturing (Brown & Gerbarg, 2005, 2009; Mason & Gerbarg, 2018). Similarly, Carney, Cuddy, and Yap (2010) found that one minute high-power physical postures (as opposed to low-power displays) can cause positive physiological, behavioural and psychological changes, including reduced levels of cortisol, an increased tolerance to risk, and experiences of strength and power.

Therefore, bottom-up yoga techniques may affect physiological dysfunctions found in GAD patients by correcting the imbalance of the ANS, by activating the parasympathetic nervous system and the GABA system via stimulation of the vagus nerve. This in turn reduces the physiological effects of stress (i.e. reducing allostatic load; Streeter et al., 2012).

### **2.2.2 Body awareness**

Bottom-up mechanisms of yoga may also cultivate body awareness which can improve resilience in GAD patients. According to Merleau-Ponty (1945), the body is a functional and unified biologically experienced organism which constitutes the centre of human subjectivity. It is a field of interpretation and bodily manifestations are understood as expressions of how an individual perceives their reality (Thornquist, 2006). Yoga may provide a gateway for

exploration of the embodied and relational self, reconnecting people to their bodies through exercising proprioception (i.e. body positioning and self-movement) and interoception (i.e. the sense of internal bodily states). These techniques enable a sensory integration and embodied experience of how an individual feels, which in turn contributes to an awareness of self-boundaries and overall sense of self (Nasrallah, 2012; Craig, 2009). Understanding what is happening in your body and how it affects your behaviour, as well as bringing awareness and acceptance to physical attributes, may enhance an individual's capability to respond to bodily signals in appropriate and adaptive ways. This is critical for recovery and maintenance of healthy behaviour (Farb & Mehling, 2016). For example, research suggests that enhanced levels of interoceptive awareness improves anxiety-related distress (e.g. Lackner & Fresco, 2016).

## **2.3 Top-down mechanisms of yoga**

Top-down processes in yoga refer to mechanisms initiated via mental processing at the level of the cerebral cortex (including regulation of attention and increased meta-awareness through yoga practices) which may activate higher order neural networks and decrease psychological stress as well as HPA and SNS activity. This in turn modulates inflammation and immune function (Taylor et al., 2010; Muehsam et al., 2017). Top-down yoga processes will be considered in relation to attention, adaptability, meta-awareness and wisdom as potential benefits of yoga for GAD.

### **2.3.1 Attention**

GAD patients tend to lack the present moment focus of attention and according to Borkovec et al. (2004) this GAD characteristic is in most need of treatment. Yoga stimulates attention to the present moment, while incorporating a highly focused awareness and attentional engagement during bodily movements (Zoogman et al., 2019). This contributes to a reduction of ruminative thought processes and negative forms of appraisal often found in GAD patients (McCall, 2007). In yoga classes, attention is frequently directed towards an external point (*drishti*) or towards a specific part of the body (such as being invited to 'press your fingertips into the mat' or 'feel the ball of your foot') to enable increased focus and balance. These techniques actualise Patanjali's fifth limb of yoga (*pratyahara*) by 'withdrawing' visionary focus away from other distractions or by redirecting attention towards internal bodily

sensations (Gard et al., 2014). This meditative mechanism of exercising concentration on specific sensations and disregarding others, enables subjective flexibility of attention and inhibitory control. Sustained attention towards purposeful information while disregarding irrelevant information, potentially improves an individual's connection to the present moment (Gard et al., 2014). These integrated meditative components of yoga have been found to decrease rumination and mind-wandering and give rise to positive emotional experiences (Hasenkamp, Wilson-Mendenhall, Duncan, & Barsalou, 2012; Aftanas & Golocheikine, 2001). Furthermore, focused grounding practices can alleviate anxiety by enhancing feelings of balance and stability (Pilkington, Gerbarg, & Brown, 2016). Yoga practice may encourage “your experience of the present moment [thereby quieting] mental turbulence that disturbs your contentment – contentment that reflects a state of being in which your peace is independent of situations and circumstances happening around you” (Chopra & Simon, 2004, p. 37).

### **2.3.2 Adaptability to the uncertain**

The teachings of yoga may contribute to enhanced adaptability to the uncertain (for example, negative environmental changes) and may thereby allow for improved management of emotionally challenging experiences (Zoogman et al., 2019). For example, yoga teachers often invite students to practice the spiritual concepts related to yoga philosophy, including the practice of acceptance of impermanence (accepting the inevitability of change and how change is an essential part of life) and compassion towards oneself and others. These techniques may enhance mindful states, encouraging the reframing of challenging situations as less stressful, and allowing the individual to accept discomfort. By “riding the wave of sensation”, accepting the truth of impermanence and learning to reframe an experience, an individual with GAD may enhance their capacity to understand their symptoms and the world around them (Faulds, 2005, p. 700). Over time a practitioner who is experiencing anxiety (e.g. body tension, racing heart and catastrophic thoughts) may learn to observe the experience without reaction, or over-identifying with their internal experience (Baer, 2003). Instead, the individual is encouraged to accommodate and reside with the bodily reactions and thoughts appearing during the practice, while observing how these expressions change (Kabat-Zin, 1990). For example, challenging yoga poses such as chair pose (*utkatasana*) can induce responses similar to the desire to escape or self-judge, yet with continual practice an individual may disconnect with these body sensations by identifying and treating them as a

transitory experience (Hayes, Orsillo, & Roemer, 2010; Mehling et al., 2011; Mason & Gerbarg, 2018). In this way, the practitioner may re-appraise stimuli by identifying thoughts and feelings as transcendent mental events and accept that such negative and positive emotions change and fluctuate (Uebelacker & Broughton, 2018).

### **2.3.3 Meta-awareness and de-centering**

Cultivating mindful self-awareness is an important aspect of yoga practice (Morgan et al., 2016). Yoga can encourage meta-awareness or self-awareness (Arora & Bhattacharjee, 2008), a mechanism where an individual recognises ‘thinking about thinking’ (Flavell, 1979). This process involves witnessing (in a conscious state) the stimuli that make specific emotions, desires, behaviours and thoughts. Yoga encourages the practitioner to explicitly observe mental and emotional fluctuations, but without wanting to modify the content of experience or make judgements; a process of “witness[ing] consciousness” allowing the observation of experience without reaction (Gard et al., 2014, p. 5; Cope, 2007). For example, in a yoga class, students are instructed to adopt a specific pose, deepen their breathing, and be mindful of, and observe, their experience without judgements. Increasing exposure to, and acceptance of, internal experiences may reduce the function of worry as an avoidance strategy by encouraging mindfulness and non-judgemental awareness of internal experiences (Roemer et al., 2008; Morgan et al., 2016). In this way, an individual with GAD practicing mindfulness can re-evaluate the usefulness of their worry and engage in a wider state of awareness that enables empowering interpretations of stress, thereby leading to significantly reduced levels of distress (Garland, Gaylord, & Fredrickson, 2011), decreased experiential avoidance and increased meta-awareness and self-regulation (e.g. Hooper, Villatte, Neofotistou, & McHugh, 2010; Gard et al., 2014).

De-centering (also known as decentration) is an additional form of meta-awareness that permits a detachment or disengagement from sensory experiences of the self in an imagined situation, which can increase the chances of favourably changing one’s behaviour (Fresco et al., 2007a; Fresco, Segal, Buis, & Kennedy, 2007b; Vago, 2014; Lebois et al., 2015). De-centering enables a shift in perspective by identifying thoughts, reactions and feelings, allowing an individual to detach sensations from self-referential experiences (Gabriel et al., 2018; Kessel et al., 2016). Similar to mindfulness, such awareness overrides short-term negative impulses (such as worry and anxiety) in favour of long-term considerations, thereby enhancing the ability to acknowledge the past, consider the present and accurately anticipate

the future (Baumeister, Masicampo, & Vohs, 2011). De-centering is a common feature of both CBT and yoga practices, considering that both therapies provide techniques aimed at changing an individuals centered thinking, encouraging the patient to take a figurative step back from their thoughts and beliefs with an open-mind (Hayes-Skelton, Calloway, Roemer, & Orsillo, 2015).

### **2.3.4 Wisdom based contemplative practice**

Patanjali's eightfold system of yoga contains many similar elements to modern psychotherapeutic treatments of GAD, including cognitive reframing, behavioural recommendations, relaxation techniques and mindfulness; in addition to methods encouraging cognitive flexibility, improved concentration, and reduction of distress (Mason & Gerbarg, 2018). However, some of the limbs of yoga are outside the typical scope of mental healthcare (Mason & White, 2018), providing more of an ethical framework for an individual's judgement of right and wrong (Gard et al., 2014). Such ethical concepts of yoga practice are rarely included in Western yoga classes but may be conveyed more informally through goal setting or technique instructions based on attitudes and awareness of self and others. In a yoga class, a practitioner may be instructed to 'set an intention' for their practice, by bringing awareness to a quality or virtue they want to cultivate more of in their lives, for example compassion or gratitude. Research has found that yoga's positive effect on perceived stress was mediated by self-compassion (Gard et al., 2012), which supports the polyvagal theory (Porges, 2017; Porges & Carter, 2017). Similarly, Gard et al. (2014) emphasise that goal setting and positive intentions encourage self-care and prosocial behaviour. In this way, yoga can be considered a 'wisdom-based' contemplative practice, by providing an ethical framework of right and wrong (Cope, 2007; Gard et al., 2014).

## **2.4 Current research into effectiveness of yoga for anxiety**

A number of narrative or qualitative reviews have identified preliminary support for the effectiveness of yoga in the treatment of anxiety (Vollbehr et al., 2018; Chugh-Gupta, Baldassarre, & Vrkljan, 2013; da Silva et al., 2009; Field, 2011; Kirkwood et al., 2005; Li & Goldsmith, 2012; Uebelacker & Broughton, 2016; Joshi & Desousa, 2012). Furthermore, there are several systematic reviews and meta-analyses exploring the effects of yoga on

anxiety (e.g. Cramer et al., 2018; Zoogman et al., 2019; Hofmann Andreoli, Carpenter, & Curtiss, 2016). Cramer et al. (2018) included six randomised controlled trials (RCT;  $N = 319$  participants), and identified limited, short-term effects of yoga on anxiety compared with no treatment ( $SMD = -0.43$ ) and large effects compared with active treatment comparisons ( $SMD = -0.86$ ), albeit the latter with substantial heterogeneity across studies ( $I^2 = 50\%$ ). Notably, Cramer et al.'s (2018) search procedures were conducted through 2016, indicating that the search may be outdated. Additionally, two of the six studies in Cramer et al. (2018) excluded yoga postures (*asana*) as a key component of the yoga intervention and three out of eight studies used non-clinical samples. One of Cramer et al.'s (2018) included studies that used a clinically diagnosed GAD sample (Gupta & Mamidi, 2013) has been found to have poor quality in other reviews (e.g. Vollbehre et al., 2018).

Zoogman et al.'s (2019) meta-analysis of RCTs suggest that yoga had a large effect on anxiety symptoms compared with the control conditions ( $d = 0.80$ ). The studies included in the meta-analysis included participants ( $N = 2295$  adults) with anxiety symptoms, rather than populations that met diagnostic criteria for an anxiety disorder, which they emphasise is a major limitation of their meta-analysis (see also thesis Zoogman, 2016). Hofmann et al. (2016) conducted a meta-analysis on *hatha* yoga for anxiety across seventeen studies ( $N = 501$ ). The meta-analysis found a small within-group effect size (Hedges'  $g = 0.44$ ) at baseline to post-intervention, and a moderate controlled effect size (Hedges'  $g = 0.61$ ). Out of the included studies, six were dissertations. Furthermore, the study included participants without anxiety, making it challenging to interpret these results. Also, Vollbehre et al.'s (2018) systematic review investigating the effects of *hatha* yoga on anxiety disorders found no significant effect of the yoga group, when compared with the active control group ( $d = -0.09$ ).

The aforementioned systematic analyses and meta-analyses have indicated potential beneficial effects and analytic support for yoga in alleviating anxiety. However, the research is based on a relatively limited number of studies and the inclusion criteria were not focused on yoga *asana*. Studies were included according to different types of anxiety or symptoms of anxiety, potentially limiting the ability to generalise these findings to clinical populations with chronic, excessive anxiety, especially to GAD samples.

Therefore, due to the prevalence and burden of GAD, together with the reported beneficial effects of yoga practice and more recent publication of clinical trials, an updated systematic review is considered relevant.

## **3 Methods**

A systematic literature review was conducted with the objective of examining and utilising relevant research and theoretical perspectives in relation to GAD and yoga. The systematic review was planned and executed according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines (Liberati et al., 2009; Moher et al., 2009). Additionally, reference was made to the recommendations of Cochrane Collaboration by actively utilising the Cochrane handbook for systematic reviews of interventions throughout the review procedure (Higgins et al., 2019a). No formal research protocol was prepared, and the systematic literature review was not recorded in any database.

### **3.1 Scoping the literature**

An exploratory scoping search was performed by using generic search terms such as “yoga” and “anxiety” in order to gain an extensive view of the existing literature on the topic. This included previous systematic reviews and meta-analyses, as well as obtaining insights regarding the grey literature (such as reports, dissertations, theses etc.) and a preliminary specification of key confounders and co-interventions. The primary objective of the scoping search was to gain an overview of the field. This search was performed using Google<sup>TM</sup> Scholar, International Journal of Yoga, the University of Oslo library search tool (Oria).

### **3.2 Eligibility criteria for this systematic review**

#### **3.2.1 Types of studies**

The Cochrane handbook advises to use RCT studies in systematic reviews as it is considered to be the best study design for evaluating the efficacy of interventions and often referred to as the ‘gold-standard’ (Cartwright, 2007). However, as this systematic review is designed to identify studies which were in naturalistic settings (such as hospital settings) and restricted to patients with a GAD diagnosis, the scoping search indicated that there were only a few studies based on RCT. Similarly, Jeter, Slutsky, Singh, and Khalsa (2015) found that yoga studies published from 1967-2013 were mainly non-randomised studies of effects of interventions (NRSI) or uncontrolled studies. According to the Cochrane handbook, if the research question cannot be answered by RCTs, inclusion of NRSI defined as “any quantitative study estimating

the effectiveness of an intervention (harm or benefit) that does not use randomi[s]ation to allocate units (individuals or clusters of individuals) to intervention groups” can also be justified (Reeves et al., 2019, p. 595). This is further supported by Britton et al. (1998) and Deeks et al.’s (2003) conclusions that in certain circumstances (for example, where RCT evidence is unavailable or where randomisation may have unethical consequences) it may not be possible to answer a systematic review question based on RCT evidence alone. According to Black (1996), Feinstein (1983) and Deeks et al. (2003), NRSI may provide more valuable evidence than that available from RCTs, including consideration of rare events, long term outcomes and adverse effects. Researchers have also argued that non-randomised studies of good quality yield results similar to RCTs (e.g. Linde, Scholz, Melchart, & Willich, 2002).

Therefore, eligibility criteria for this systematic review were defined as all relevant study designs (RCTs and NRSI) from all countries published in English, comparing yoga and GAD to a comparison group (e.g. waitlist control group). For the purpose of this systematic review, journal articles were determined as the primary source of interest. Such articles can be found easily, data can be extracted quickly and typically include useful information about methods and results (Lefebvre et al., 2019). Other types of publications (e.g. dissertations) were excluded. No publication date or publication status restrictions were imposed. As the lack of a concurrent control group may impose difficulties in concluding on the effectiveness of an intervention (Booth, Sutton, & Papaioannou, 2016), studies with no control or comparison group were excluded. Studies describing the same study (or part of a study) relating to another article were excluded.

### 3.2.2 Types of intervention

This systematic review has operationalised yoga according to multicomponent interventions combining postures (*asana*), breathing exercises (*pranayama*) and meditation (*dhyana*). Thus, yoga interventions which incorporate physical postures and meditative practices and/or breathing exercises based on yoga theory are included. Furthermore, previous research has found that there are no differences in styles of yoga and that all yoga styles have their value (e.g. Cramer et al., 2016). Therefore, all yoga traditions, including *hatha*, *vinyasa*, *ashtanga*, *bikram*, *viniyoga*, *kundalini*, *kripalu*, *anusara*, *sudarshan kriya* and *iyengar* are considered in scope (see definitions of yoga styles in Appendix D). No restrictions were made regarding intervention length or frequency. All types of control groups (for example: no treatment, treatment-as-usual, active control or co-interventions) were included. Studies omitting yoga

postures (*asana*) as a major part of the intervention, such as mindfulness-based stress reduction and mindfulness-based cognitive therapy interventions, were excluded as these studies are based on seated meditation and body scan interventions, with limited yoga postures (*asana*).

### **3.2.3 Types of participants**

Adults between the age of 18-65 years, irrespective of gender, race or nationality, having received a GAD diagnosis (corresponding to the criteria by the DSM including DSM-1, DSM-2, DSM-3, DSM-4, DSM-5 or by International Classification of Disease [ICD], including ICD-9 and ICD-10) with or without psychiatric conditions (e.g. depression) or medical conditions (e.g. hypertension) comorbidity were considered eligible. Both outpatients and inpatients were included. Exclusions were made for non-clinical samples, menopausal or pregnant females, as well as participants who had previous experience with yoga, as these factors were considered to potentially influence outcome measures (e.g. Curtis, Weinrib, & Katz, 2012; Shepherd-Banigan et al., 2017; Field, 2016).

### **3.2.4 Types of outcome measures**

Anxiety was operationalised according to validated and reliable measurements exploring changes in symptoms or level of anxiety. This included outcome measures exploring changes in anxiety which could be self-reported or observed by using a range of measurement tools or instruments (including scales, questionnaires, interviews, or physiological measurements). Eligible outcome measures could include either a continuous measure of improvement or a dichotomous measure of remission of anxiety symptoms, at both pre- and post-intervention, and using a validated self-report scale (e.g. State and Trait Anxiety Inventory, STAI; Spielberger & Gorsuch, 1983). Studies not having anxiety as an outcome variable were excluded.

## **3.3 Search methods for identification of studies**

According to the Cochrane handbook (McKenzie et al., 2019), the starting point for developing a search strategy for a systematic review of interventions should consider the main concepts being examined, including search terms for the participants (P), interventions (I) and

study designs (S) evaluated. The search strategy for this systematic review was constructed according to diagnosis and intervention and compiled together with Hege Kristin Ringnes (a librarian working for the University of Oslo) and subsequently adjusted by the main author of this systematic review (HSP). A comprehensive and thorough systematic literature search was completed using search engine databases, including MedLine® ovid (1946 to April 15, 2020) and PsycINFO® ovid (1806 to April 20, 2020).

The key search words for participants (P) included the terms related to anxiety (e.g. “Generalized and Anxiety and Disorder\*”) and were combined with the “OR” Boolean operator to achieve sensitivity within concepts. When searching for yoga interventions (I), no restrictions were made to the type of yoga tradition and therefore multiple search terms were included to identify all relevant studies that have used yoga interventions for health-related purposes. Additionally, Patanjali’s eight limbs of yoga were also included to conduct a broader search (e.g. “Asana\*”). An asterisk (\*) was used as a truncation, and wildcards (?) were used to find British and American spellings. Terms to search for the types of study design (S) to be included were deemed inappropriate, no use of the Boolean operator “NOT” was used in the search strategy as this feature is likely to exclude relevant literature (Booth et al., 2016). As such, no search filter was used to retrieve a particular set of records. Key terms used for the MedLine® ovid search are listed in Table 1.

Furthermore, the main author of this systematic review (HSP) manually reviewed reference lists of relevant literature extracted from the database search and identified potential studies. Search algorithms were designed for MedLine® ovid and adopted to the requirements of PsycINFO® ovid. A literature search in MedLine® ovid and PsycINFO® ovid was conducted from inception (September 2019) to February 2020. A search update was performed in MedLine® ovid on the 15th April 2020 and on PsycINFO® ovid the 20th April 2020.

Table 1.  
Search Strategy for Medline® ovid Database

#	Search word	Result
1	exp *Anxiety/	43721
2	(Generalized and Anxiety and Disorder).mp.	8353
3	exp *Anxiety Disorders/di, px, th [Diagnosis, Psychology, Therapy]	25972
4	or/1-3	73747
5	exp *Yoga/	2226
6	Yogic*.mp.	368
7	(yama* or niyama* or asana* or pranayama* or pratyahara* or dharana* or dhyana* or samadhi*).mp.	7130
8	(hatha* or vinyasa* or ashtanga* or bikram* or viniyoga* or kundalini* or kripalu* or sudarshan kriya* or Iyengar*).mp.	740
9	(mind adj3 body).mp.	6753
10	or/4-9	16182
11	4 and 10	317

### 3.4 Study selection

Eligible studies resulting from the search were selected for inclusion by the main author of this systematic review (HSP) in an unblinded manner. The eligibility assessment was performed based on inclusion criteria. The main author of this systematic review (HSP) screened the eligible records based on titles and abstracts to remove irrelevant reports. Records were then sequentially excluded based on full-text reports.

### 3.5 Data collection process

When journal articles appeared to be relevant from an initial assessment perspective, the full-text reports were retrieved and reviewed according to eligibility criteria. The researcher of this systematic review (HSP) assessed all potential articles for inclusion independently. Data was collected using a data extraction sheet based on the Cochrane data collection form for intervention reviews for RCTs and non-RCTs Version 3 (Li, Higgins, & Deeks, 2019; Cochrane Collaboration, 2014a). Where appropriate, the study authors were contacted for additional information to further clarify study eligibility.

### 3.6 Data items

Details were extracted and coded from each study according to various inclusion and exclusion criteria. The criteria were based on selection criteria and procedure, participants

characteristics, yoga intervention characteristics, control or comparison group characteristics, aspects of the methodology, outcome measure characteristics and general characteristics (e.g. number of patients per group etc.).

### **3.7 Risk of bias in individual studies**

For the purpose of this systematic review, bias is defined as “a systematic error, or deviation from the truth, in results” (Boutron et al., 2019, p. 117). Risk of bias was addressed by ensuring that the final decision for data selection and inclusion was completed independently, by a single reviewer (HSP). The methodological quality of the selected RCTs was assessed by using the RoB-2 tool, a revised Cochrane risk-of-bias tool for randomised trials (Sterne et al., 2019; Higgins, Savović, Page, & Sterne, 2019c) and for non-RCTs was assessed by the risk of bias in non-randomized studies of interventions (ROBINS-I) tool (Sterne et al., 2016a; 2016b). Final risk of bias assessments was made by combining both the RoB-2, ROBINS-I and the criteria described in the Cochrane handbook (Higgins et al., 2019b; Reeves et al., 2019) in order to evaluate the design and particular features of the eligible studies. Thus, risk of bias was assessed in 8 domains: confounding bias, selection of participants into the study, classification of intervention, deviation from intended intervention, missing data, measurement of outcomes, selective reporting and overall bias.

Each domain was assessed according to low, moderate, serious or critical risk of bias, or no information. As there were no meaningful variations in bias between outcomes, bias was assessed per study rather than by outcome-specific categories. The overall risk of bias was considered to be ‘serious risk of bias’ if a serious risk was identified in at least one domain, on the condition that no critical risk of bias was identified in any domain. If no serious risk of bias was identified in any domain, the study was considered to have an overall ‘moderate risk of bias’.

### **3.8 Summary measures**

The primary outcome of interest in this systematic review is continuous measures (i.e. symptoms of anxiety as measured by questionnaires: STAI [Spielberger & Gorsuch, 1983], Hamilton Anxiety Rating Scale [HAM-A; Hamilton, 1959], and GAD-7 [Spitzer, Kroenke, Williams, & Löwe, 2006]), of treatment effects.

For continuous measures, the natural effect measure is the difference in means, therefore the standardised difference in means (*SDM*) with 95 % confidence intervals were calculated, divided by the pooled standard deviation. Where no means or standard deviations were available, they were calculated from the median and interquartile ranges (Toschi-Dias et al., 2017), or requests were made to obtain the missing data from the respective authors.

Cohen's (1998) guidelines<sup>1</sup> for interpreting the magnitude of *SMD* in social sciences were utilised in order to evaluate treatment effects. A negative effect of *SMD* suggests favourable effects of yoga compared with the control intervention for anxiety (e.g. decreased anxiety symptoms), whereas a positive *SMD* suggests beneficial effects favouring other interventions compared with yoga (e.g. treatment-as-usual).

### 3.9 Planned synthesis of treatment effects

The planned method of synthesis of results was to conduct a meta-analysis, a statistical technique which combines and provides a weighted average of the results of two or more studies (Deeks, Higgins, & Altman, 2019). The meta-analysis was intended to provide an overall statistic (and associated confidence interval) summarising the effects of the yoga interventions, compared with a control intervention, on a specific clinical outcome (GAD).

Studies considered reasonably homogeneous regarding interventions and designs, while also reporting sufficient details in study results, were considered candidates for the meta-analysis. Statistical heterogeneity between studies was analysed using the chi-square test  $I^2$  statistic, representing a measure of how much variance between studies can be attributed to real differences between studies, rather than to chance. The magnitude of heterogeneity was categorised as  $I^2 = 0-24$  % demonstrating a consistent effect on the outcome variable and therefore low heterogeneity:  $I^2 = 25-49$  % moderate heterogeneity:  $I^2 = 50-74$  % substantial heterogeneity: and  $I^2 = 75-100$  % considerable heterogeneity (Deeks et al., 2019). As such, heterogeneity  $>50$  % was considered to have highly varied and inconsistent effects across studies.

Where available data allowed further analysis, meta-analysis was calculated by applying the Review Manager 5.3 (Cochrane Collaboration, 2014b). Studies that were not considered sufficiently homogeneous were combined using a random-effects model. A

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<sup>1</sup> *SMD*: 0.2-0.5 categorised as small, *SMD*: 0.5-0.8 as moderate, *SMD*  $> 0.8$  as large effect sizes.

random-effects model gives a result that may be considered as an ‘average intervention effect’ (Booth et al., 2016; Deeks et al., 2019). If no measure of dispersion was given, the original investigators of included studies were contacted to request missing data.

### **3.10 Risk of bias across studies**

Risk of publication bias across the studies will be examined by using a funnel plot and Egger’s test if at least 10 studies were included in the meta-analysis (Sterne et al., 2011). If the funnel plots are displayed as asymmetric, and the  $p$ -value of the Egger’s test is 0.1 or lower, there is an indication of publication bias (Egger, Smith, Schneider, & Minder, 1997).

## 4 Results

### 4.1 Search results and final selection process

The preliminary search through MedLine® ovid and PsycINFO® ovid yielded a total of 565 records and 533 records remained after removing duplicates. The majority of these articles (see Figure 1) were discarded during the initial screening phase because the studies tested various mind-body interventions (such as mindfulness-based interventions) rather than yoga interventions. Additionally, the studies considered a variety of anxiety conditions (not just GAD), healthy populations and included non-relevant outcomes. The remaining 41 studies were subjected to a full-text evaluation. An additional study was identified through intersecting reference lists of previous systematic reviews on similar topics. This article was also retrieved for detailed evaluation and assessed for eligibility, making a total of 42 studies. Studies were disqualified due to the following reasons: not meeting the diagnostic criteria for GAD psychiatric disorder (DSM or ICD classification), being published in a foreign language, having no (or no adequate) comparison groups (uncontrolled studies) or having critical risk of bias according to the RoB-2 or ROBINS-I tool. The search identified one ongoing trial (clinical trial identification: NCT01912287; see Hofmann et al., 2015). The selection process is shown in Figure 1. As a result, four studies were considered to satisfy the inclusion criteria and were retained for further analysis. In the following sections, for structural purposes, the included studies will be referred to as ‘study 1’ (Chad-Friedman et al., 2019), ‘study 2’ (Falsafi, 2016), ‘study 3’ (Gabriel et al., 2018), and ‘study 4’ (Toschi-Dias et al., 2017) as shown in Table 2.

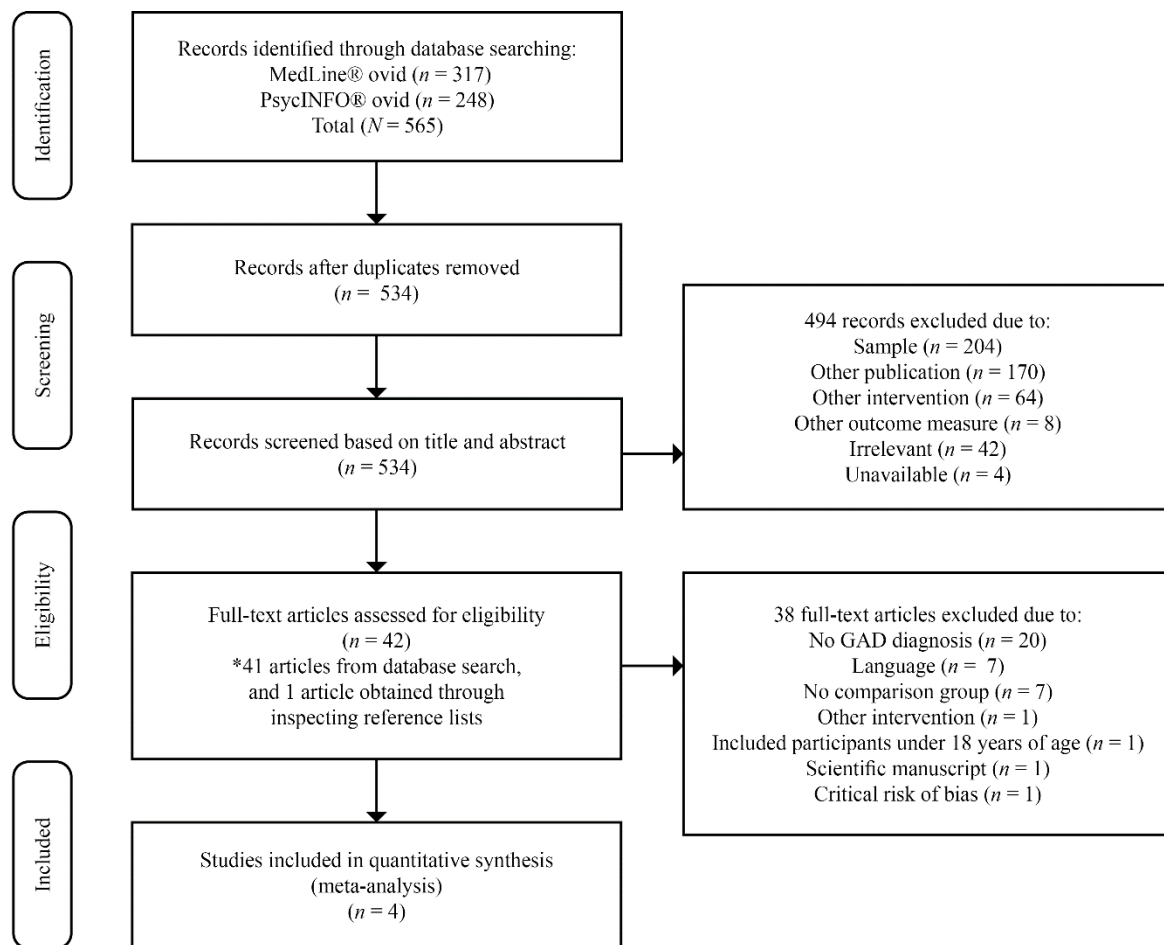


Figure 1. Literature search flowchart.

## 4.2 Study characteristics

Study characteristics of each included study is shown in Table 2. All studies were published in English between 2017 and 2019. Of the studies included, three studies were performed in the US (study 1; 2; 3) and one in Italy (study 4). The total number of participants was 704, ranging from 46-542 ( $M = 176$ ).

Table 2.  
Characteristics of Included Studies

Study #, first author (Year), origin	Study design	Diagnosis	Sample	Yoga intervention	Therapist characteristics	Comparison group	Assessment timepoints	Measures
1. Chad-Friedman et al. (2019), USA	NRSI	MINI	N = 542 (104*) Age: 18 ≥ Mean age: 35.3 Gender: 51 % female Ethnicity: 82.70 % Caucasian Comorbidity: Multiple disorders	Intervention: Yoga, unspecified Duration: 50 min. Frequency: One time only Follow up: None Setting: Groups Home practice: None	Certified E-RYT500 and C-IAYT yoga instructor	Comparison: TAU Duration: 2 weeks Frequency: NI Follow-up: None Setting: Individual therapy Homework: None	Baseline Post-intervention	Primary: - PANAS Secondary: - PHQ-9 - GAD-7 - CGI-I - PC
2. Falsafi (2016), USA	RCT	DSM-IV-criteria, unstructured interview	N = 67 (23*) Age: 18-50 Mean age: 22.1 Gender: 86.40 % female Ethnicity: 88 % Caucasian Comorbidity: 58.20 % GAD and MDD	Intervention: <i>Hatha</i> yoga Duration: 8 weeks Frequency: 75 min per week Follow-up: 12 weeks Setting: Groups Home practice: Encouraged	Certified yoga instructor, training in trauma-sensitive yoga, psychiatric clinical specialist, and certified holistic nurse	Comparison: Control group Duration: 8 weeks Frequency: None Follow-up: 12 weeks Setting: NI Homework: Journaling	Baseline (pre) 4 weeks (mid) 8 weeks (post) 12 weeks (follow-up)	Primary: - BDI - HAM-A - SSI - SCS - CAMS-R
3. Gabriel et al. (2018), USA	NRSI	DSM-IV-criteria, unstructured interview	N = 49 (34*) Age: 24-75 Mean age: NI Gender: 100 % female Ethnicity: NI Comorbidity: 28 % GAD and MDD	Intervention: <i>Kundalini</i> yoga Duration: 8 weeks Frequency: 75 min. per week Follow-up: None Setting: Groups Home practice: Encouraged	Certified <i>kundalini</i> yoga instructor, and licensed social worker	Comparison: TAU Duration: 8 weeks Frequency: 60 min. per week Follow-up: None Setting: Individual therapy Homework: None	Baseline Post-intervention	Primary: - SCL-90-R Secondary: - STAI - BAI - BDI-II
4. Toschi-Dias et al. (2017), Italy	NRSI	DSM-IV-criteria	N = 46 (24*) Age: 32-51 Mean age: NI Gender: 63 % female Ethnicity: NI Comorbidity: 24 % GAD and PDD	Intervention: SKY Duration: 15 days, 10 sessions Frequency: 120 min. a day Follow up: None Setting: NI Home practice: NI	NI	Comparison: TAU Duration: 15 days Frequency: NI Follow-up: None Setting: NI Homework: NI	Baseline Post-intervention	Primary: - HAM-A - HAM-D - SCL-90 - CAC

Note. MINI = Mini-International Neuropsychiatric Interview; DSM-IV = Diagnostic and Statistical Manual of Mental Disorders; PANAS = Positive and Negative Affect Schedule; PHQ-9 = The Patient Health Questionnaire; GAD-7 = Generalized Anxiety Disorder 7-item scale; BDI = Beck Depression Inventory; BDI-II = Beck Depression Inventory-II; SSI = Student-life Stress Inventory; SCS = Self-Compassion Scale; CGI-I = Clinical Global Impression scale-Improvement; CAMS-R = Cognitive and Affective Mindfulness Scale Revised; SCL-90-R = Symptom Checklist 90 - Revised; SCL-90 = Symptom Checklist 90; STAI = Spielberger State Anxiety Inventory; BAI = Beck Anxiety Inventory; HAM-A = Hamilton Rating Scale for Anxiety; HAM-D = Hamilton Rating Scale for Depression; NI = no information; CAC = cardiac autonomic control; E-RYT500 = 500-hour Yoga Teacher Yoga Alliance; C-IAYT = International Association of Yoga Therapist; GAD = generalised anxiety disorder; MDD = major depressive disorder; PDD = persistent depressive disorder; TAU = treatment-as-usual; SKY = sudarshan kriya yoga; USA = United States of America; RCT = randomised control trial; NRSI = nonrandomised studies of intervention; \* = number of participants receiving the yoga intervention.

### 4.2.1 Participants

All studies examined adult clinical populations (between 18-75 years old) with a GAD diagnosis. The diagnosis was made according to the MINI international neuropsychiatric interview (Sheehan et al., 1998; study 1), or assessed by a clinician (or other healthcare professional) based on the DSM-5 (American Psychiatric Association, 2013) criteria for GAD (study 2; 3; 4). Several reported participants were comorbid and met criteria associated with other mental disorders, with the majority having both depression and GAD (ranging from 24-59 % comorbidity). Most participants were female (55 %), with one study including only females (study 3). Two studies recruited inpatient participants from a psychiatric hospital (study 1; 4), one recruited outpatient university students (study 2) and the remaining study recruited outpatient participants from a community sample (study 3). For studies reporting ethnicity, the majority of the participants were Caucasian (study 1; 2).

### 4.2.2 Interventions

Interventions across studies were moderately different in how they were delivered, their intensity, duration, amount of homework practice and style of yoga. The length of the yoga interventions differed between one session (study 1) and eight weeks of practice (study 2; 3). The frequency of the sessions ranged from 50 minutes (study 1) to 120 minutes (study 4). The intensity varied from 8 sessions in 8 weeks (study 2; 3) to 10 sessions in 2 weeks (study 4). In two studies, daily yoga practice at home was encouraged with the necessary equipment (e.g. videos, written descriptions of yoga poses and yoga props; study 2; 3), whereas in the remaining two studies it was unclear whether participants were encouraged to practice yoga outside of the intervention setting (study 1; 4).

Treatments included different yoga traditions. One study was based on the *sudarshan kriya* yoga (SKY) tradition (study 4), one on the *hatha* yoga tradition (study 2), and one on the *kundalini* yoga tradition (study 3). The remaining study did not specify which yoga teaching the intervention utilised, but from the descriptions in the text it can be interpreted to belong to the *hatha* yoga tradition (study 1). In three of four studies, the authors provided details on the experience and qualifications the yoga teachers in the intervention has. For example, in study 1, the yoga teacher was certified as an E-RYT500 (Yoga Alliance) and International Association of Yoga Therapists (IAYT) yoga instructor.

The structure of the yoga interventions was slightly different. For example, the beginning of the yoga classes in study 3 contained explorations related to the patient's anxiety symptoms, whereas study 1 and 2 started their classes with seated meditation practices, and study 4 with seated breathing exercises. Common to all yoga activities is the incorporation of physical yoga postures, meditation, and relaxation, whilst focusing on the moment to moment awareness of the self, including observation of physical sensations and breathing. Three studies did not include follow-up procedures, except for one study which measured outcomes at 12 weeks after intervention completion (study 2).

The comparison group was treatment-as-usual in three studies (study 1; 3; 4) and a 'no intervention' waitlist control group in one study (study 2). One study (study 2) also compared an active intervention (mindfulness) to the control group.

### **4.2.3 Outcomes measures**

All studies included anxiety self-report questionnaires with good internal validity and reliability. All studies assessed symptoms of anxiety by using either the STAI (Spielberger & Gorsuch, 1983; study 3; 40 items;  $\alpha = .90$ ), HAM-A (Hamilton, 1959; study 2; 4; 14 items;  $\alpha = .89$ ) and GAD-7 (Spitzer et al., 2006; study 1; 7 items;  $\alpha = .89$ ). In studies measuring the outcome variable using multiple scales (e.g. the Symptom Checklist-90 revised in study 3; Derogatis & Spitz, 2000), selection was based on the perceived most suitable anxiety scale in the subsequent analysis. All studies measured outcomes immediately or shortly after interventions.

Most studies reported baseline and post-intervention data except for study 1, and study 4 did not report means and standard deviations for the baseline and post-intervention assessment. These authors were contacted for the means and standard deviations to calculate effect sizes for all studies.

## **4.3 Risk of bias within studies**

The methodological quality and judgements of the three NRSI and one RCT were assessed individually for each domain (see Table 3). All studies had serious risk of bias in two or more domains. In the following text, a brief description of risk of bias assessments made for each domain will be explained (detailed risk of bias assessments can be found in Appendix E).

Table 3.  
*Assessment of Risk of Bias of Included Studies*

Study #, first author (Year)	Confounding bias	Selection of participants	Classification of intervention	Deviations from intended intervention	Missing data	Measurement of outcomes	Selective reporting	Overall bias
1. Chad-Friedman et al. (2019)	Moderate	Serious	Low	Serious	Serious	Serious	Serious	Serious
2. Falsafi (2016)	Serious	Moderate	Low	Serious	Moderate	Serious	Low	Serious
3. Gabriel et al. (2018)	Moderate	Serious	Low	Serious	Moderate	Serious	Serious	Serious
4. Toschi-Dias et al. (2017)	Serious	Serious	Low	Serious	Moderate	Serious	Low	Serious

*Note.* Judgements made independently by HSP.

### 4.3.1 Confounding bias

Few studies reported making any statistical adjustments for confounding variables and therefore failed to consider potential confounders. Risk of bias from confounding variables was considered serious when at least one important confounding variable was not appropriately controlled for (i.e. no adjustment or limited adjustment). For example, an important confounding variable across studies is controlling for medication effects and concomitant treatment. A serious risk of confounding bias was observed in two studies (study 2; 4) and moderate for two studies that applied a propensity score based on potential baseline confounders (study 1; 3).

### 4.3.2 Selection of participants into the study

All three NRSI studies were considered to be subject to selection bias due to the non-randomised nature of the study designs and were therefore assessed as serious risk of bias for this domain (study 1; 3; 4). In both study 3 and 1 self-selection biases were observed (treatment allocation was determined by participant preference) and selection was based on clinician assignment in study 1.

In the RCT study, a computer number generator was utilised to assign participants into groups (study 2). However, concerns were identified as the random assignment was stratified by gender, and randomisation occurred within the feasible timeframe of the participants schedules, both of which override a true randomisation procedure. Additionally, the allocation concealment method was not explicitly described in this study. Thus, bias arising from the randomisation process was deemed as moderate risk of bias for the RCT study (study 2).

### **4.3.3 Classification of intervention**

Bias due to misclassification of intervention status was assessed as low risk of bias for all studies (study 1; 2; 3; 4). Yoga interventions were clearly defined, suggesting that misclassification of interventions was unlikely. For instance, in study 1 the yoga intervention was described using a pre-written protocol and study 4 used a predefined treatment programme manual (SKY).

### **4.3.4 Deviations from intended intervention**

Bias from deviations of the intended intervention may arise from systematic differences between the yoga intervention and comparison groups (such as deviations due to differences in expectation of treatment between the yoga and comparison group), also referred to as performance bias. Knowledge of intervention groups may impact physiological and behavioural outcomes (Higgins et al., 2019c). Furthermore, departures from the intended intervention can also include non-specific treatment effects such as yoga teacher enthusiasm, relationship with the teacher, or expectation of the treatment: any of which may have influenced participants expectations and outcome assessments (Holtzman & Beggs, 2013; Posadzki, Lizis, & Hagner-Derengowska, 2011).

Performance bias may be eliminated or minimised by utilising blinding procedures (for instance preventing the researchers from knowing who is allocated to which treatment groups). No study in this systematic review reported blinding of participants or personnel. Nevertheless, blinding procedures would have been problematic in the selected studies due to the nature of yoga interventions (Higgins et al., 2011; Brown & Gerbarg, 2005). However, previous yoga research has performed blinding procedures, such as in de Manincor et al. (2016) where participants were blinded to initial group allocation, or Field et al. (2012) where all questionnaire evaluations were executed by trained research professionals who were blinded to the study hypothesis and to participant assignment.

Additionally, in study 2 and 3 both intervention and comparison groups were performed by the same instructor. Allegiance bias (bias resulting from the researcher's allegiance to a specific school of thought) may have occurred since the authors themselves instructed the yoga interventions. All study procedures including recruitment, screening, intervention application, and outcome measures were conducted by the main researcher in

study 2 and 3. The instructors of the interventions were proponents to the type of school of yoga instructed.

Bias due to deviations from intended intervention was therefore assessed as serious risk for all studies (study 1; 2; 3; 4) since participants and personnel were aware of intervention groups and inadequate blinding of participants was considered likely to influence subjective outcomes.

#### **4.3.5 Missing data**

Risk of bias was considered moderate when either there was no missing data, or a substantial amount of missing data appeared to be present, but it was accounted for in the analysis.

With regards to missing participants, study 2 provided information about the reasons for withdrawals, whereas explicit details were not stated in study 4. In study 1 and 3 there were several missing participants in the yoga and comparison group due to administrative issues. However, in study 3 the missing data was accounted for with full information maximum likelihood and all available information was used to estimate the results, and in study 1 the lost data was not used in their final analysis. As such, risk of bias is assessed as moderate for these studies (study 1; 3).

With regards to missing summary data, study 1 did not obtain data of their primary outcome (affect measures) among the comparison group. The proportion of reason and control for missing data in the analyses was not statistically accounted for, and the study was therefore deemed as a serious risk of bias due to missing data.

It is unclear whether study 4 had bias due to missing data. No information was reported about missing data or the potential for data to be missing. Additionally, other potential missing data issues can be considered in relation to missing data variables, such as standard deviations, which were not reported. Thus, study 4 is also assessed as moderate risk of bias for missing data.

#### **4.3.6 Measurement of outcomes**

All studies were at serious risk of bias in the measurement of outcomes. The outcome measures were subjective and thus susceptible to being influenced by participants awareness of the intervention (study 1; 2; 3; 4). According to Higgins et al. (2019c) the level of expectation (and personal interest) for the outcome assessor regarding the positive effect of an

intervention increases if the comparison is no treatment or treatment-as-usual. If an outcome assessor is aware of the nature of the intervention, bias could be introduced as the outcome may be influenced by knowledge of the intervention itself (Higgins et al., 2019c). Blinding of outcome assessors aims to prevent systematic variations in measurements between intervention groups and could have been considered in the studies to account for bias in the measurement of outcomes (Higgins et al., 2019c). As aforementioned, the method of blinding may be inappropriate in yoga studies and not performed for practical reasons (Higgins et al., 2011; Brown & Gerbarg, 2005). However, blinding data analyses can be performed in yoga research, as outcome assessments may be done by blind raters (Butler et al., 2008; Uebelacker et al., 2017). Also, all studies except study 1 were at risk of recall bias since the studies used the same questionnaires at admission and discharge.

#### **4.3.7 Selective reporting**

Bias due to selective reporting was considered serious in two studies as only significant results were reported (study 1; 3), and low in the remaining two studies, as there was no reason to suspect selective reporting (study 2; 4). Only study 4 provided a pre-registered protocol (clinical trial identification: NCT02828072).

#### **4.3.8 Overall bias**

Based on the assessment of various categories of risk of bias within the individual studies, the results presented in this review are associated with studies exposed to an overall serious risk of bias. Notably, adverse events or safety-related data were not stated in any study.

### **4.4 Effects of yoga interventions**

To explore the effects of yoga interventions for GAD patients with or without comorbidity, three examinations were conducted. Firstly, baseline and post-intervention comparisons of self-reported anxiety scores of the outcome measures for the various yoga interventions were examined to estimate the intervention effect. Secondly, where feasible, the post-intervention records were pooled to derive a summary estimate of treatment effects, reflecting the difference in variation between groups. Since there was substantial diversity in the settings and interventions, a random-effects meta-analysis was carried out. Thirdly, the primary

researcher of the study review (HSP) qualitatively reviewed data on the potential mechanisms of yoga for GAD patients in the included studies.

Many of the results presented in the selected articles were considered scarce. Despite requests for additional data to enable effect size calculations, one of the authors was unable to provide further information (study 1). Additionally, in one study (study 3), due to interest in the short-term effects of the yoga interventions, only the mean difference on the STAI-S measure (rather than the STAI-T) was explored in the meta-analysis. For the same study, the Beck Anxiety Inventory (BAI; Beck & Steer, 1993) measure was not explored in the meta-analysis since the comparison variables to the control condition were not provided.

#### **4.4.1 Effects of yoga at baseline to post-intervention**

Three of four studies reported statistically significant reductions in anxiety symptoms from baseline to post-intervention assessment for participants in the yoga intervention group (see Table 4). Due to limitations of reporting yoga and anxiety scores further analyses were not possible for study 1. Table 4 provides details of the treatment effects at each site at the end of yoga intervention for each study.

No mean or standard deviation were available in one study (study 4). The authors reported the median and interquartile ranges for the HAM-A scale at baseline and post-intervention. Thus, calculation of the means and standard deviations from the sample size ( $n$ ), median ( $m$ ) and interquartile ranges ( $q1$  and  $q3$ ) were done by using the following formulas (Wan, Wang, Liu, & Tong, 2014):

$$\bar{X} \approx \frac{q_1 + m + q_3}{3}.$$

$$S \approx \frac{q_3 - q_1}{\eta(n)}$$

Table 4.  
Self-reported Effects of Yoga at Baseline and Post-intervention by Anxiety Measures

Study #, first author (Year)	Outcome measure	Baseline <i>M</i> ( <i>SD</i> )	Post-intervention <i>M</i> ( <i>SD</i> )	<i>n</i>	<i>p</i>
1. Chad-Friedman et al. (2019)	GAD-7	NI	NI	104	NI
2. Falsafi (2016)	HAM-A	21.20 (8.00)	14.50 (8.30)	23	<.010
3. Gabriel et al. (2018)	STAI-T	46.28 (11.99)	40.53 (11.09)	29	<.010
	STAI-S	42.41 (13.22)	34.62 (12.27)	29	<.010
	BAI	14.94 (8.50)	8.89 (7.55)	19	<.010
4. Toschi-Dias et al. (2017)	HAM-A	18.25 (5.52)	12 (7.88)	24	<.005

Note. GAD-7 = Generalized Anxiety Disorder 7-item scale; HAM-A = Hamilton Anxiety Rating Scale; STAI-T = Speilberger State Anxiety Inventory-Trait; STAI-S = Speilberger State Anxiety Inventory-State; BAI = Beck Anxiety Inventory; NI = no information; *M* = mean, *SD* = standard deviation; *n* = sample size; *p* = *p*-value.

#### 4.4.2 Effects of yoga compared with control condition

To compare the effects of yoga on symptoms of anxiety compared to control groups, one RCT (study 2) and two NSRIs (study 3; 4) were obtained.

Results reveal evidence for large short-term effects of yoga on anxiety compared to either treatment-as-usual (study 3, 4) and wait-list control group (study 2) (*SMD* = -0.92; 95 % *CI* = -1.28, -0.56; *p* < 0.001). No evidence of heterogeneity was found for this subgroup estimate (*I*<sup>2</sup> = 0 %, *p* = .41).

This result indicates that across studies, participants in the yoga intervention group scored lower on anxiety measures compared to control groups after completing intervention. The overall pooled effect estimate indicates a greater decrease in symptom severity for the yoga group compared with waitlist and treatment-as-usual control groups, with results favouring the yoga group.

Table 5.

Treatment Effects (SMD and 95% CI) of Yoga Group Compared With Comparison Groups on Anxiety Symptoms

Study #, first author (Year)	Yoga group			Control group			% weight	SMD IV, Random, 95 % CI
	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>		
2. Falsafi (2016)	14.50	8.30	23	20.30	8.40	23	36.80	-0.68 [-1.28, -0.09]
3. Gabriel et al. (2018)	34.62	12.27	29	50.27	10.95	15	27.80	-1.30 [-1.98, -0.61]
4. Toschi-Dias et al. (2017)	12.00	7.89	24	19.33	8.72	22	35.40	-0.87 [-1.48, -0.26]
Total (95 % CI)			76			60	100.00	-0.92 [-1.28, -0.56]
Heterogeneity: $Tau^2 = 0.00$ ; $Chi^2 = 1.80$ , $df = 2$ ( $p = 0.41$ ); $I^2 = 0\%$								
Test for overall effect: $Z = 4.99$ ( $p < .0001$ )								

Note. CI = confidence interval; IV = inverse variance; SD = standard deviation; SMD = standardised mean difference.

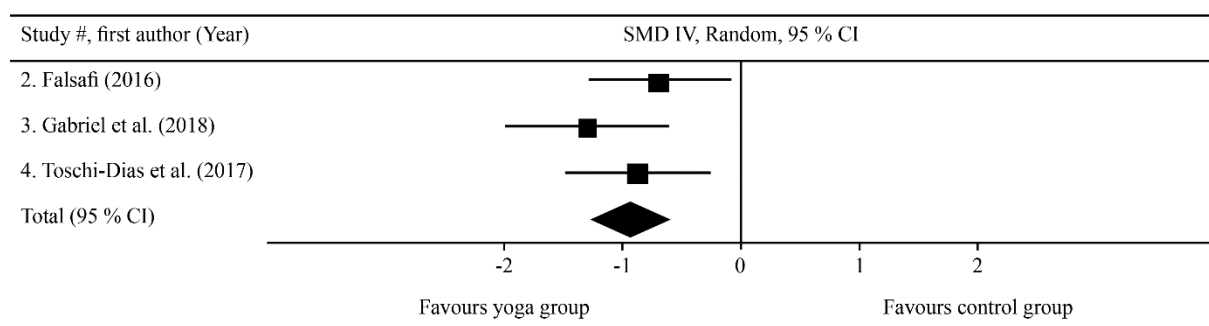


Figure 2. Forest plot demonstrating the standardised mean difference (SMD) effect sizes with 95 % confidence intervals (CI) for anxiety symptoms at post-intervention.

Note. <sup>a</sup> Horizontal lines represent 95 % confidence interval (CI). <sup>b</sup> Weights are from random effect analysis.

#### 4.4.3 Exploration on potential mechanisms of yoga

Two out of four studies used in the systematic review reported findings related to the potential mechanisms of yoga for GAD patients. Study 3 conducted mediation analyses to examine potential treatment mechanisms of the yoga intervention and found that changes in somatic symptoms mediated the treatment efficacy on changes in symptom severity ( $B = 0.17$ ,  $SE = 0.02$ ; 95 %  $BC\ CI = 0.04, 0.31$ ). The indirect effect explained 42 % of the variance in decline in anxiety symptom severity. Furthermore, study 4 found that the yoga group had significantly higher parasympathetic modulation and cardiorespiratory coupling and lower sympathetic and cardiac autonomic control compared with the treatment-as-usual group at post-intervention.

## **4.5 Risk of bias across studies**

Due to the limited number of relevant studies and significant amount of heterogeneity across all included studies, the Egger's test and funnel plot examination was not assessed, in line with recommendations for meta-analysis; "use of the test with substantially fewer than 10 studies would be unwise" (Sterne et al., 2011, p. 4; Egger et al., 1997).

## 5 Discussion

In discussing the results of this systematic review, consideration will be given to the evidence provided by relevant research, the challenges associated with the included studies, the strengths and limitations with regard to the systematic review, and the wider implications of this analysis together with future directions for further evaluation.

### 5.1 Summary of evidence

The aim of this evaluation is to execute a systematic review of the research evidence in relation to the effectiveness of yoga as a treatment for GAD, with or without comorbidity. The psychophysiological perspectives of this study have identified that the primary symptom of GAD is worry, which may lead to reduced autonomic flexibility as a result of low cardiac vagal tone (e.g. Hoffman et al., 2008; Thayer et al., 1996; Porges, 2003). Yoga, through mindful physical movement, breathing techniques and meditation, may correct for the imbalances in the ANS and stimulate the vagal tone, thereby reducing allostatic load and cultivating physical and psychological well-being (Streeter et al., 2012).

A comprehensive systematic search identified four studies fulfilling the inclusion criteria. Except for one study (study 1), all reported significant results. The studies showed reduced self-reported levels of anxiety after yoga interventions when compared with baseline and post-intervention outcomes. When comparing the effects of yoga interventions with control conditions, pooled effect sizes indicated a larger decrease in anxiety symptom severity for the yoga group. Additionally, when qualitatively exploring the potential mechanisms of yoga, one study (study 3), found that changes in somatic symptoms mediated the outcome of the yoga intervention. Additionally, study 4 reported that the yoga intervention influenced the PNS by increasing parasympathetic modulation and cardiorespiratory coupling, while lowering cardiac autonomic control and sympathetic modulation. However, the limited number of studies included in this systematic review, together with the relative absence of high-quality methodology, do not permit firm conclusions to be drawn. Thus, caution is warranted in interpreting the results, and findings from this systematic review should be considered as preliminary.

## 5.2 Interpretation of results in context of other systematic reviews and meta-analyses

Similar to other systematic reviews and meta-analyses exploring yoga's effectiveness in reducing symptoms of anxiety (e.g. Cramer et al., 2018; Zoogman et al., 2019; Hofmann et al., 2016), the current evaluation suggests that yoga interventions may provide evidence for alleviating anxiety symptoms. This review differentiates itself from previous systematic reviews and meta-analyses by providing specific insights into clinical populations diagnosed with GAD and including studies with a holistic yoga approach. Additionally, the search executed included more recent research evidence.

Previous systematic reviews and meta-analyses have found a larger effect of yoga amongst non-clinical samples. Zoogman et al. (2019) found that effect sizes were numerically smaller for clinical samples ( $d = 0.43$ ) compared with non-clinical anxiety samples ( $d = 0.88$ ). Similarly, Cramer et al. (2018) found no effects of yoga for patients diagnosed with an anxiety disorder by the DSM manual criteria. Nevertheless, this evaluation did find that yoga alleviated anxiety symptoms amongst GAD samples compared with control ( $SMD = -0.92$ ).

In contrast to previous systematic reviews, this evaluation included a one-session yoga intervention (study 1) contributing to originality of this evaluation. Study 1 examined the outcomes of yoga in a real-life naturalistic setting in a partial hospitalization environment. Little is known about the potential benefits of yoga for psychiatric symptoms as a complement to evidence-based treatment during partial hospitalization. Therefore, including a study placed in a naturalistic setting is considered a positive contribution to the current systematic review. Out of the four studies included, study 1 found non-significant effects of yoga on anxiety symptoms post-intervention. These results can be attributed to the limited length of intervention (one-session) in contrast to interventions in the other included studies, offering multiple yoga sessions over a longer period.

### 5.2.1 Potential mechanisms of yoga

This evaluation has presented yoga mechanisms based on a framework that combines yoga with physiological, psychological, and behavioural processes (see Chapter 2). Yoga may affect autonomic functioning by increasing parasympathetic activity (and thereby decrease excitation of cardiovascular systems and hyperarousal) through an integration of bottom-up and top-down mechanisms (e.g. Gard et al., 2014; Muehsam et al., 2017; Porges, 1995b). This

systematic review includes a qualitative exploration of potential mechanisms of yoga in the included studies. Yoga benefits identified by study 3 were associated with changes in somatic symptoms, thereby mediating the intervention efficacy on changes in symptom severity. The authors attributed these changes to yoga's potential to foster de-centering and meta-awareness (see section 2.3.3), which in turn conveys a beneficial effect on somatic symptoms, thereby contributing to the reduction in anxiety symptoms. These results indicate that decreased severity in somatic symptoms may be linked to reduced anxiety. Nevertheless, it is important to note that yoga can alleviate anxiety through a number of mechanisms. Even though the authors find that anxiety relief can be statistically explained by fewer somatic symptoms, these symptoms may also correlate strongly with other psychological mechanisms, such as improved self-efficacy (Bandura, 1982). In study 4, yoga was associated with greater parasympathetic modulation and cardiorespiratory coupling, together with decreased sympathetic and cardiac autonomic control. These findings support the polyvagal theory (Porges, 2001). Furthermore, it is reasonable to assume that various mechanisms have different individual contributions to the effects of yoga. For example, the physical aspect of yoga may regulate autonomic inflexibility and increase parasympathetic activity, thereby increasing physiological well-being. However, it may not influence the negative effects of ruminative thought patterns.

## **5.3 Challenges associated with the included studies**

### **5.3.1 The yoga teachers**

The yoga teacher's qualifications in the included studies are considered both variable and limited in the context of understanding the clinical and psychological implications of GAD. For example, relevant experience varies; in study 2 the yoga teacher was a holistic nurse and psychiatric clinical nurse specialist, while yoga instruction was given by a social worker in study 3 (see Table 2). Additionally, the authors provide yoga teacher qualification details in three of four studies, including IAYT certifications (study 1). Since 2012, the IAYT has published a curriculum for yoga therapists requiring 800 hours of study (Yoga Alliance, 2014 as cited in Verrastro, 2014). However, qualifying as a clinical psychologist in the United States requires four-years of undergraduate schooling followed by an average of seven years graduate training (American Psychological Association, 2012, as cited in Patwardhan, 2016).

As such, yoga teacher-training programmes clearly do not compare with extensive psychotherapy and professional qualification programmes (Patwardhan, 2016; Forbes, Akhtar & Douglass, 2011). For yoga to be part of a psychiatric treatment it is therefore recommended that patients are supervised by a skilled yoga therapist with relevant training and experience in psychotherapy.

### **5.3.2 The yoga interventions**

Despite the incorporation of overlapping elements in yoga interventions (including physical postures, meditation and breathing techniques) the styles of yoga, and length and structure of the interventions, varied in the studies included in this systematic review. These differences make direct comparisons between studies challenging. Nevertheless, previous research emphasises that all yoga styles have therapeutic value (Cramer et al., 2016; Cramer & Lauche, 2018) and there is no ‘one size fits all’ approach to yoga (Cramer & Lauche, 2018). Therefore, yoga interventions should be adapted to a specific population’s requirements, abilities and preferences. For example, although relaxation is essential in a yoga intervention for treating GAD, people with high anxiety may find it difficult to begin the yoga classes with restorative poses due to their high sympathetic drive and mind-wandering (Gerbarg & Mason, 2018). This is further supported by de Manicor et al. (2016) who developed individualised yoga sessions based on therapeutic applications of classical yoga as part of their intervention. It is therefore recommended that future clinical trials should consider individualising yoga treatments to meet patients’ needs both in terms of yoga mechanisms, and the duration and frequency of the yoga sessions.

Additionally, the settings of the experimental and comparison groups were substantially different between the studies and this may have influenced the results. As beforementioned, three of the studies used treatment-as-usual as a comparison group (study 1; 3; 4). Group formats varied substantially, from individual one-to-one therapy (treatment-as-usual) to a group setting (yoga intervention). Yoga interventions may have been positively influenced by collective support and group dynamics (Ravindran et al., 2009, as cited in Ravindran & da Silva, 2013) as the group format may enhance a patient’s sense of belonging and improve access to emotional support (Wren, Wright, Carson, & Keefe, 2011). Furthermore, in two studies (study 1; 3), there was a disproportionate distribution between the yoga group and the control group, which may have influenced the outcome.

As beforementioned, all procedures were conducted by the same instructor in study 2 and 3. Since the instructors were proponents to type of yoga taught, there is an increased risk that the researcher may have influenced the findings to match their hypothesis.

### **5.3.3 Methodological quality**

This evaluation confirms many of the methodological challenges in yoga studies that have been identified in previous systematic reviews and meta-analyses (e.g. Zoogman et al., 2019; Cramer et al., 2018). All the included studies were rated with serious risk of bias for several reasons. Bias arose due to a choice of analysis method that did not allow for controlling confounding variables or missing data, lack of assessments by independent assessors and blinding procedures, small sample size and the use of self-report measures. While it is recognised that blinding procedures propose a technical challenge for yoga interventions (Higgins et al., 2011; Sterne et al., 2016b; Brown & Gerbarg, 2005), the lack of accurate blinding of outcome evaluations, and high or uncertain risk of performance bias, increases the ambiguity and validity of the documented outcomes.

### **5.3.4 Absence of active comparisons and placebo control conditions**

Generally, meta-analyses are designed to compare differences between an active treatment and control condition (Bandelow et al., 2015). Active comparisons may promote a more rigorous test of effects of yoga and can be used to determine the relative efficacy of a treatment by demonstrating a comparative efficacy above and beyond what might be obtained from another active treatment (Zoogman et al., 2019; Wampold & Imel, 2015). However, active comparisons and placebo control conditions were not well represented in this systematic review. One study, which was included in the review during the preliminary phase (see Figure 1; Gupta & Mamidi, 2013) had an active comparison group, yet was excluded at a later eligibility stage due to critical risk of bias (Sterne et al., 2016a; Sterne et al., 2019). Similarly, psychological placebo control groups were not utilised as comparison groups in the included studies. Placebo control conditions are typically used to control for non-specific treatment effects (such as yoga teacher attention, relationship with teacher, group support and expectancy to treatment; Wampold & Imel, 2015; Holtzman & Beggs, 2013; Posadzki et al., 2011). While designing and deploying psychological placebos is often challenging as there

are many non-specific factors (Wampold, Minami, Tierney, Baskin, & Bhati, 2005 as cited in Zoogman et al., 2019), this study recommends implementing placebo control conditions in future research.

### **5.3.5 The sample**

There are several limitations with regards to the samples in the included studies. For those studies reporting ethnicity, the majority of the participants were Caucasian (study 1; 2; see Table 2), limiting the sample groups to Western populations, which may not be representative for other geographical locations or ethnic groups. For example, in a study assessing the benefits of yoga for lower back pain, Combs and Thorn (2014) found that non-Hispanic blacks reported significantly higher levels of catastrophizing and fear of movement, compared with non-Hispanic whites. There may also be cultural barriers in exercising yoga. Attitudes towards yoga may play a role in considering yoga as a treatment and cultural differences in yoga's appropriability and acceptability may bias the outcome. For example, withdrawing from yoga classes has been found to be associated with the spirituality component of yoga due to a mismatch with personal beliefs (e.g. Katzman et al., 2012). Similarly, Zoogman et al.'s (2019) meta-analysis found larger support for Indian samples compared with Caucasian, indicating that yoga maps onto Eastern beliefs more easily than Western.

Although GAD is predominantly associated with female populations, women are disproportionately represented in all included studies. Previous research suggests that mind-body therapies appeal more to females and that females are more likely to engage in yoga interventions compared with men (Barnes, Powell-Griner, McFann, & Nahin, 2004; Uebelacker et al., 2017). Therefore, considering that the samples were self-selected, participants may have a prejudice towards yoga and its potential effects. Furthermore, all studies except study 1 were based on small sample sizes and can thus be exposed to imprecise estimates and questionable conclusions.

## **5.4 Strengths and limitations of this systematic review**

This systematic review provides preliminary evidence for effective treatments for GAD and insight into the potential mechanisms of yoga. It is based on a comprehensive search strategy with multiple sources of information and an explicit methodology to ensure transparency and

potential reproducibility (following the PRISMA guidelines and Cochrane handbook recommendations). The review assessed the methodological quality of individual studies, as well as emphasising clinically important outcomes related to the efficacy of the yoga interventions under consideration. All studies provide valuable information, and three of four studies provide promising results.

Nevertheless, this study has a number of limitations and areas for improvement. The results and conclusions of a meta-analysis are only as good as the results of the studies included in the analysis (Colliver, Kucera, & Verhulst, 2008). Only four studies were included in this systematic review and they all had an overall serious risk of bias and low quality of evidence. The following section will discuss strengths and limitations at review-level, in relation to the literature search, screening procedure, findings and considerations of long-term safety data.

#### **5.4.1 The literature search**

This evaluation is based on a comprehensive search strategy utilising multiple widely recognised sources of information (MedLine® ovid and PsycINFO® ovid) to increase the likelihood of identifying relevant studies. Although the literature search was extensive, the number of eligible studies was low as a result of the rigid exclusion and inclusion criteria (see 5.4.2). Several studies excluded during the literature search were uncontrolled studies, usually with a repeated measures design with one condition (yoga group), or simply looked at changes in anxiety symptoms without a formal diagnosis (e.g. Khalsa, Greiner-Ferris, Hofmann, & Khalsa, 2015; Doria et al., 2015; Dhansoia, Bhargav, & Metri, 2015; Tiwari, Sutton, Garner, & Baldwin, 2019; Katzman et al., 2012). Perhaps a less stringent inclusion criteria would yield larger samples. Additionally, studies could have been omitted due to limitations in database interfaces, poor indexing, and poor choice of search terms, which may have imposed bias and reduced search precision.

#### **5.4.2 The screening procedure**

The search strategy is considered a strength in this evaluation. It was compiled together with a librarian from the University of Oslo and used a predefined inclusion criteria. However, due to time and resource constraints, the screening procedure of potential articles was performed systematically by a single researcher (HSP). According to the Cochrane handbook, the

screening procedure to determine whether each study meets the eligibility criteria (and to eliminate the chance that relevant studies may be erroneously discarded) should be executed by at least two people working independently (Lefebvre, et al., 2019; Li et al., 2019). As such, relevant articles may have been missed or overlooked because of screening fatigue.

Nevertheless, case reports have also suggested that single screening approaches may be adequate (Doust, Pietzak, Sanders, & Glasziou, 2005; Shemilt et al., 2014).

The accuracy of judging relevant and valid studies can be influenced by predefined opinions, preferences, and prejudice, specifically for experts in a particular field (Cooper & Ribble, 1989). The main author of this systematic review (HSP) is a certified yoga instructor and yoga therapist, and although the review has strived to be as transparent and objective as possible, by clearly documenting and justifying all processes and decisions, some level of allegiance bias in the screening process cannot be excluded.

An important point for consideration in this review is the scarcity of relevant literature in relation to the research question. For example, during the screening procedure, no eligible studies from Eastern countries were found. Most yoga practices are considered to be based on ancient Eastern teachings (Krisanaprakornkit, Sriraj, Piyavhatkul, & Laopaiboon, 2006) and previous systematic reviews have shown that yoga studies based on Eastern populations have the largest effects on anxiety symptoms (e.g. Zoogman et al., 2019). Reasons for the absence of studies from Eastern regions can be attributed to these studies being published in non-indexed journals, or that the studies are unpublished, or that they have non-significant findings that have not been published or identified (e.g. the file drawer problem; Krisanaprakornkit et al., 2006). Additionally, the eligibility criteria were restricted to studies published in English, indicating that cross-cultural variations may not be considered. Notably, research has found that there is a cultural difference in anxiety diagnosis (Khambaty & Parikh, 2017), and it is therefore recommended that cultural factors should be considered.

### **5.4.3 The findings**

The quality of the studies included were assessed according to risk of bias, quality of reporting and quality of methodology or design. Performing a risk of bias analysis is considered an advantage in the current systematic review. This ensures a mechanism to assess the strength of the body of evidence and ensure transparency and reproducibility (Boutron et al., 2019). For the purpose of this systematic review it was deemed appropriate to combine elements from both RoB-2 and ROBINS-I risk of bias tools to arrive at an estimate of bias.

Earlier research identified challenges associated with an appropriate integration of evidence from NRSI and RCTs into an evidence assessment (Schünemann et al., 2019). Similar to the screening procedure, although it is advised to use at least two independent reviewers with an agreed process for consensus and defined transparency standards when evaluating risk of bias (e.g. Viswanathan et al., 2012), only one independent researcher (HSP) carried out these assessments.

A meta-analysis was conducted to synthesise results on the effect of yoga as a treatment for anxiety symptoms, compared with treatment-as-usual and control groups. Advantages of meta-analyses include precision improvements (narrow confidence interval), the ability to answer new questions not considered in individual studies, and an opportunity to challenge conflicting claims (Deeks et al., 2019). Such a synthesis of the findings is particularly important for systematic reviews incorporating NRSI, as NRSI designs are presumed to be more susceptible to certain biases when evaluating the effects of interventions (Robertson et al., 2014) and may vary with respect to their “intrinsic ability to estimate the causal effect of an intervention” (Reeves et al., 2019, p. 595). These biases are presumed to be averaged out through the synthesis and thus provide a more reliable effect estimate (Colliver, et al., 2008). In contrast, disadvantages of meta-analysis include the risk of showing deceptive results, particularly if the validity of the studies are low, or if there are flaws in the design, or when certain biases are not considered (Deeks et al., 2019; Higgins et al., 2003; Boutron et al., 2019). Also, studies of low quality are typically associated with favourable results (Booth et al., 2016). The meta-analysis in this review is based on studies which are considered to have both high levels of bias and low relative quality, and the results can therefore be considered preliminary.

A final limitation in this systematic review relates to not conducting the statistical risk of publication bias. As aforementioned, the number of included studies were insufficient to be able to estimate publication bias using the Egger’s test and funnel plots (Sterne et al., 2011; Egger et al., 1997). The potential presence of publication bias would imply that the findings of this systematic review may not be reliably interpreted.

#### **5.4.4 The lack of long-term safety data**

No adverse safety-related data (e.g. transient worsening symptoms) was reported in the studies included. As it is unclear whether the reasons for the lack of safety-related data is due to no presence of adverse events, or because there was no protocol to measure it, this

systematic review concludes incomplete reporting of safety-related data. Notably, although there was no reporting on safety-related data, study 2 (p. 495) emphasises that the yoga instructor of the interventions had experience in trauma-sensitive yoga, and provided “a psychologically safe place” whilst “using trauma-sensitive language when instructing participants”. Additionally, the strenuous versions of yoga poses were disregarded on purpose for safety reasons (study 2).

Furthermore, only study 2 provided follow-up measurements at 12 weeks. However, previous research has emphasised the need for longer term data measures, preferably at three and six months (Brown & Gerbarg, 2005) and lack of long-term safety data beyond six months in yoga research is therefore considered to be a limitation (Butler et al., 2008).

Although the included studies are concluded to lack long-term safety related data, reported side effects of yoga are rare and tend to be mild and transient (Pilkington, Kirkwood, Rampes, & Richardson, 2005). Occasionally however, meditation-induced mania or psychotic episodes have been reported in vulnerable patients with or without a history of psychosis (e.g. Kuijpers, van der Heijden, Tuinier, & Verhoeven, 2007; Ernst, 2001) and migraine headaches which improved after discontinuing yoga (Sherman et al., 2005). Additionally, single cases of serious adverse effects have occurred, most probably arising from incorrect yoga practice (e.g. Campos et al., 2017; Pilkington et al., 2005). Cramer, Krucoff, and Dobos (2013, p. 7) suggested that yoga can “be recommended to patients with physical or mental ailments, as long as it is appropriately adapted to their needs and abilities and performed under the guidance of an experienced and medically trained yoga teacher”. According to Mason and Gerbarg (2018), safety is the most important factor for individuals with anxiety disorders. Therefore, adequate safety and tolerability data is necessary to improve knowledge related to optimal clinical use of yoga interventions (Ravindran & da Silva, 2013). Further research is required to determine whether yoga is a safe and effective intervention in treating anxiety (Zoogman et al., 2019) and a consultation with a healthcare provider should be considered mandatory before commencing yoga (Ernst, 2001; Pilkington et al., 2005).

## **5.5 Wider implications for implementing yoga interventions**

This systematic review makes novel and important contributions to a broader understanding of the wider implications of yoga interventions in clinical practice, by providing preliminary

quantitative evidence to support yoga as an effective treatment for anxiety symptoms. The evaluation has emphasised the psychophysiological characteristics of GAD and how specific yoga mechanisms can help alleviate anxiety symptoms. This evaluation included studies exploring populations that met the criteria for GAD, as well as studies with a holistic approach to yoga.

Although a number of limitations have been identified, the findings provide preliminary evidence to suggest that yoga is a valuable tool for alleviating anxiety symptoms in GAD samples. This review may provide critical information for researchers and policy makers who plan to apply yoga to clinical practice or develop and evaluate similar interventions in the future. More extensive, well-designed clinical trials are required to provide an evidence-based verification of the benefits of yoga interventions compared to standard care, psychotherapy or pharmacotherapy. Cost benefit analyses would also be beneficial to ensure optimal service efficiencies and clinical resource allocations (Krisanaprakornkit et al., 2006).

Various considerations must be taken when evaluating the implications of yoga for clinical practice, whether used as an adjunct or standalone treatment. It is essential that the individual patient's values, beliefs, attitudes, culture, needs and preferences should be considered for the treatment to have an effect (Lambert, 1992; Wampold, 2015). According to Wampold (2015), there are several ways to adapt the treatment to a patient's culture, for example, by adapting the language, arranging cultural rituals and explanations. Considering that yoga is an old scripture language with spiritual elements, patients can experience that yoga conflicts with religious or spiritual beliefs (Combs & Thorn, 2014). Therefore, to avoid potential cultural conflicts in this area, yoga treatments should emphasise the mental tools, scientific evidence, anatomy and techniques of yoga, rather than the spiritual components (Patwardhan, 2016).

The knowledge, attitude and skill of the yoga therapist must also be considered to ensure a successful implementation of yoga interventions in a clinical setting. It is imperative to cultivate a positive working environment towards both complementary therapies and potential intervention effects (Waddington et al., 2017). In this context it has been noted that when the instructor is an integral member of the clinic, it is more likely that the clinic is supportive to both the intervention and its potential benefits, cultivating a 'clinic mission' and eliminating potential barriers towards yoga interventions (Waddington et al., 2017).

## 5.6 Future directions

While the findings of this systematic review are encouraging, future empirical efforts are required in order to clinically validate the effectiveness of the yoga interventions. Extending the current systematic review or conducting future RCTs should address the aforementioned limitations, in addition to other avenues for future empirical efforts. Future studies considering yoga and GAD would benefit from using double-blind designs with placebo controls and active comparisons, more follow-up procedures to investigate the application of yoga for treatment-resistant GAD patients and larger, well-designed conduction of RCTs. Including yoga as part of a clinical treatment requires that patients are managed by a skilled yoga practitioner with training in therapy. Furthermore, there is a need for adequate safety and tolerability data for optimal clinical use (Ravindran & da Silva, 2013). Future research should also provide sufficient information concerning the yoga interventions to allow future systematic reviews and more refined meta-analyses of potential moderators (Vollbehr et al., 2018; Zoogman et al., 2019).

It is also imperative to clarify the mechanisms that mediate and moderate any therapeutic benefits of yoga, to increase our understanding of the specific factors contributing to the differential effectiveness of the yoga interventions. For example, possible mediators to test include mindfulness (Baer, 2013) and stress (Kiecolt-Gaser et al., 2010). Furthermore, it is essential that future studies can conduct moderator analyses where possible. For example, in relation to the yoga tradition in which the instructor has been schooled (e.g. *kundalini*; Hamilton-West, Pellatt-Higgins, & Sharief, 2019), the determination of the number of sessions necessary for improvement and an examination of the differences between individual and group settings (de Manincor et al., 2016). Focus could also be given to the effectiveness of individual yoga practices (e.g. just meditation) as opposed to combined practices (e.g. physical exercises, breathing exercises and meditation) when analysing the positive effects of yoga.

From a diagnostic perspective, future studies could benefit from implementing well-established diagnostic criteria systems (implemented by trained physicians familiar with anxiety diagnosis) to enhance clinical homogeneity (Krisanaprakornkit et al., 2006).

Rather than using self-report measures, future evaluations could consider more objective outcomes that probe neurophysiological and endocrinal effects, such as heart rate variability, commonly measured by electrocardiogram without impeding the practices (Chalmers et al., 2014; Brown & Gerbarg, 2005). Additionally, future research could include

a qualitative (e.g. interviews, focus groups, participant observation) examination of patients' experience of the yoga intervention and potential reasons for participation and withdrawal. In this way, research can identify the individuals most likely to benefit from participation and thus gain insight into potential cost savings (Hamilton-West et al., 2019).

Further value could also be gained by developing a codified yoga treatment for GAD, comparable to mindfulness-based interventions such as the mindfulness-based stress reduction programme. This type of standardisation would decrease the heterogeneity of yoga interventions and thereby enable more conclusions to be made. The heterogeneity of yoga interventions in current literature limits the ability to generalise findings (Zoogman et al., 2019).

## 6 Conclusion

This systematic review was conducted to investigate the effects of yoga on GAD, with or without comorbidity. Given the high prevalence of GAD and the suffering and deleterious consequences it has for a patient, effective treatments are both urgent and essential. Yoga interventions have been shown to alleviate anxiety symptoms more effectively than other types of exercise (Streeter et al., 2010). Yoga encourages a shift in awareness from negative emotions to more adaptive, self-reflected and self-regulatory cognitions (Mehling et al., 2011), and physiological changes by balancing the ANS activity (Porges, 2001).

This evaluation explores the theoretical rationale for implementing yoga interventions for patients with GAD and critically reviews the empirical evidence for the efficacy of yoga on patients with GAD. It is based on a comprehensive search strategy with multiple sources of information, provides an explicit methodology to ensure transparency and potential reproducibility, as well as emphasising clinically important outcomes related to the efficacy of the interventions under consideration. Only four studies were considered eligible and all had an overall serious risk of bias and low quality of evidence. These methodological weaknesses also limit the findings generalisability. Therefore, the findings of this evaluation are considered encouraging, yet too preliminary to draw any conclusions or support any firm recommendations. Future directions emphasise the need for enhanced methodologies, more specific yoga intervention outcome studies for GAD samples and the execution of additional RCTs enabling enhanced meta-analyses (Vollbehr et al., 2018).

In conclusion, the findings from this review highlight a need for more extensive knowledge and further yoga therapy research to optimise and standardise yoga interventions for GAD and improved mental health.

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# Appendices

## Appendix A: Generalised anxiety disorder diagnosis criteria (DSM-5)

Table 1A.

*Diagnosis Criteria Derived from Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (American Psychiatric Association, 2013).*

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### Diagnostic Criteria 300.02 (F41.1)

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- A. Excessive anxiety and worry (apprehensive expectation), occurring more days than not for at least 6 months, about a number of events or activities (such as work or school performance).
  - B. The individual finds it difficult to control the worry.
  - C. The anxiety and worry are associated with three (or more) of the following six symptoms (with at least some symptoms having been present for more days than not for the past 6 months): **Note:** Only one item is required in children.
    - 1. Restlessness or feeling keyed up or on edge.
    - 2. Being easily fatigued.
    - 3. Difficulty concentrating or mind going blank.
    - 4. Irritability.
    - 5. Muscle tension.
    - 6. Sleep disturbance (difficulty falling or staying asleep, or restless, unsatisfying sleep).
  - B. The anxiety, worry, or physical symptoms cause clinically significant distress or impairment in social, occupational, or other important areas of functioning.
  - C. The disturbance is not attributable to the physiological effects of a substance (e.g., a drug of abuse, a medication) or another medical condition (e.g., hyperthyroidism).
  - D. The disturbance is not better explained by another mental disorder (e.g., anxiety or worry about having panic attacks in panic disorder, negative evaluation in social anxiety disorder [social phobia], contamination or other obsessions in obsessive-compulsive disorder, separation from attachment figures in separation anxiety disorder, reminders of traumatic events in posttraumatic stress disorder, gaining weight in anorexia nervosa, physical complaints in somatic symptom disorder, perceived appearance flaws in body dysmorphic disorder, having a serious illness in illness anxiety disorder, or the content of delusional beliefs in schizophrenia or delusional disorder).
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## Appendix B: Explanation of a typical yoga class

Table 1B.

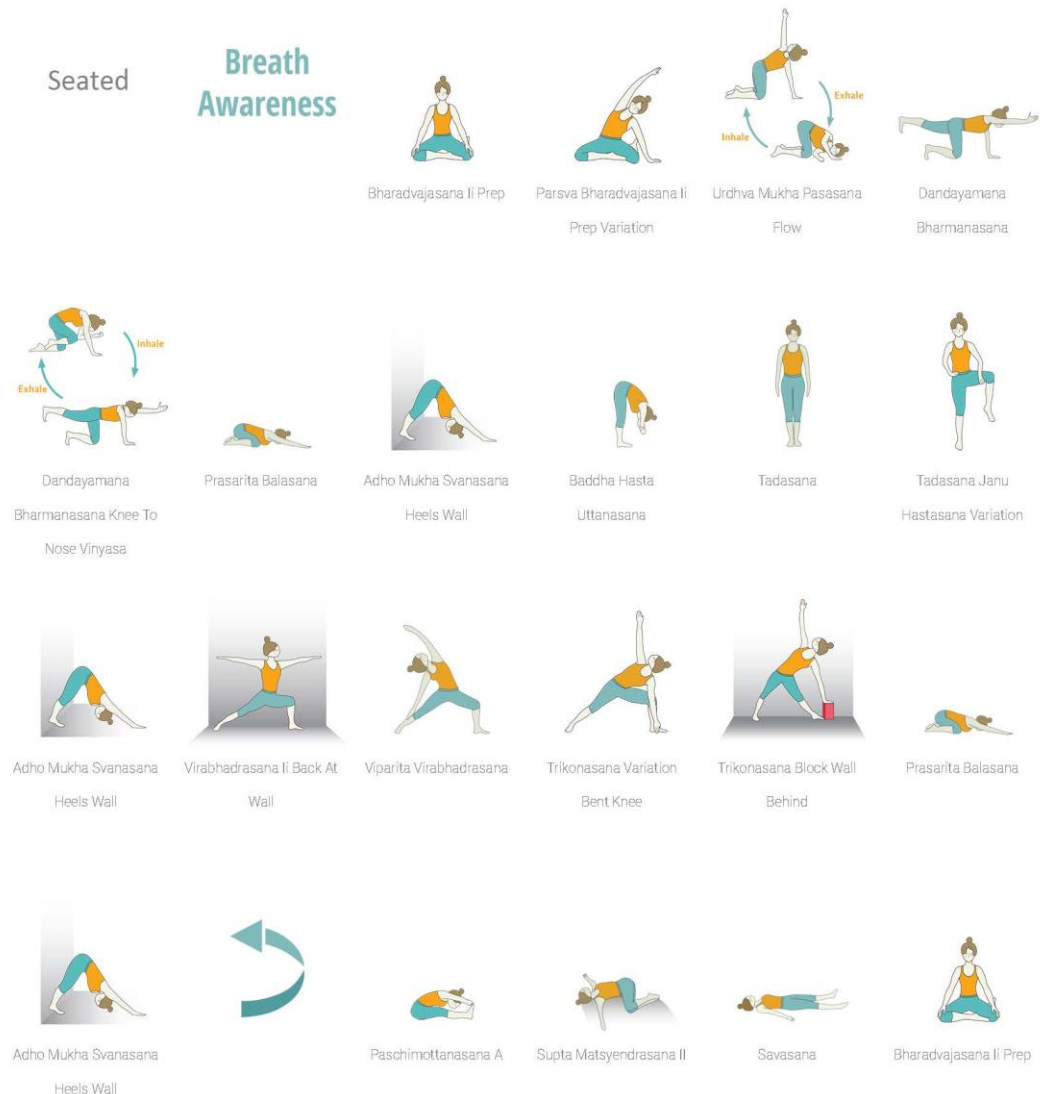
*An example of a common yoga sequence.*

Part	Description
Introducing yoga class	Seated guided meditation with an opening <i>mantra</i> to encourage presence and ‘here-and-now’ focus. Students are often encouraged to set an intention for their practice.
Initial warming	Preparing the body for <i>asana</i> practice to synchronize movements with breath and prevent injuries.
Physical postures	Yoga teachers can help improve the breathing process in those students who suffer from anxiety with simple yoga poses; static positions and dynamic movements that are practiced in synchronicity with the breath. Example of postures: <ul style="list-style-type: none"> <li>Grounding postures</li> <li>Heart-opening postures</li> <li>Seated sun salutations</li> <li>Hip openers</li> <li>Seated twists</li> </ul>
Breathing techniques	Practicing different breathing techniques ( <i>pranayama</i> ) to balance the nervous system.
Relaxation and meditation	Seated guided meditation. The practitioner is encouraged to focus inward, be attentive of the present moment, and practice acceptance towards themselves and others.
Closing practice	Silent reflection and acknowledging the practice. Usual posture: <i>savasana</i> (deep relaxation while lying supine).

*Note.* The information in this table is based on Chad-Friedman et al. (2019) and Iyengar (1979).

## Appendix C: Visual example of a typical yoga class

### Yoga for anxiety



Made by Benedikte Ingrid Austad and Hannah Strøm-Pedersen

*Figure 1C.* A yoga sequence compiled by psychologist Benedikte Ingrid Austad and the main author of this systematic review, Hannah Strøm-Pedersen, as part of their exam for Oslo Yoga's therapy training by Maja Thune. This yoga sequence was designed for individuals with anxiety disorders and was developed through the programme Tummee.

## Appendix D: Explanation of different yoga styles

Table 1D.

*A brief explanation of the different yoga styles utilised in the search procedure of this systematic review.*

Yoga style	Explanation
<i>Hatha</i>	<i>Hatha</i> yoga is a physical style of yoga with focus on breathing, meditation and transitional postures (Riley, 2004). This style of yoga was developed in the first part of the 20 <sup>th</sup> century by T. Krishnamacharya. Many styles of yoga practiced are variations of hatha yoga (such as Iyengar).
<i>Vinyasa</i>	<i>Vinyasa</i> , meaning ‘breath-synchronized movement’ is a flowing and fluid yoga style. <i>Vinyasa</i> emphasises conscious moving between vigorous postures with coordinated breathing. This yoga style was developed in the late 1990s by T.K.S. Desikachar from <i>Ashtanga</i> yoga (Ubelacker et al., 2010; Long, 2011; da Silva, Ravindran & Ravindran, 2009).
<i>Ashtanga</i>	<i>Ashtanga</i> is a vigorous style of yoga consisting of breathing and moving in a progressive series of postures. The practitioner rapidly moves from one posture to the next, usually with five breath counts between each posture. This style of yoga was developed by Sri K. Pattabhi Jois during the 20 <sup>th</sup> century (Maehle, 2011).
<i>Bikram</i>	<i>Bikram</i> yoga consist of a series of 26 postures and two breathing techniques practiced in room heated to 35-41°C, with a 40 % humidity to increase flexibility. Also known as ‘hot’ yoga (Tracy, & Hart, 2013).
<i>Viniyoga</i>	<i>Viniyoga</i> consist of gentle postures and incorporates breathing and chanting exercises (Kraftsow, 1999).
<i>Kundalini</i>	<i>Kundalini</i> yoga is a flowing yoga style with emphasis on mind-body awareness, chanting, visualisation and breathing techniques (Gabriel et al., 2018). This style of yoga may emphasise the spiritual aspects of yoga, by focusing on energy points ( <i>chakras</i> ) that stimulate the spiritual energy ( <i>kundalini</i> ). This style of yoga was developed by Harbhajan Singh Khalsa during the 1960s (Shannahoff-Khalsa, 2004).
<i>Kripalu</i>	<i>Kripalu</i> yoga incorporates dynamic gentle postures in combination with breathing and meditation. Emphasises emotional and spiritual aspects of yoga. This style of yoga was developed by Amrit Desai (after his mentor Swami Kripalvananda) in the 1960s (Faulds, 2005).
<i>Sudarshan kriya</i>	<i>Sudarshan kriya</i> is a comprehensive yoga programme including breathing techniques, gentle yoga poses and meditation, aimed at calming the practitioner and balancing the autonomic nervous system. This style of yoga was developed by Sri Sri Ravi Shankar in 1981 (Doria, Vuono, Sanlorenzo, Irtelli & Mencacci, 2015).
<i>Iyengar</i>	<i>Iyengar</i> is a yoga style derived from <i>hatha</i> , which emphasises proper body alignment and sustained postures with the help of yoga props/assistance (such as straps and blocks). Breathing and meditation during the postures play an important role. This style of yoga was developed by B.K.S. Iyengar in the 1950s (Shapiro et al., 2007).

*Note.* There are additional styles of yoga not listed here.

# Appendix E: Detailed risk of bias assessment

Study 1: Chad-Friedman et al. (2019)

<i>Risk of bias</i>		
Bias	HSP judgement	Support for judgement
Confounding bias	Moderate	Applied a propensity score based on potential baseline confounders. Demographic variables (age, gender, ethnicity/race, and education), number of days in the programme, diagnosis, and symptom severity (anxiety and depression) were controlled for.
Selection of participants into the study	Serious	<p>No allocation concealment, allocation based on self-selection (volunteers).</p> <p>No random sequence generation due to study design: non-randomised controlled study, allocation based on self-selection (volunteers).</p> <p>The health professional in charge of selecting participants into the study based their decision on whether they believed the yoga intervention would be clinically beneficial for the individual, whether the patient was physically able to engage in the yoga practice and whether the patient had interest in yoga.</p>
Classification of intervention	Low	A E-RYT500 (Yoga Alliance) and C-IAYT (International Association of Yoga Therapists) certified yoga instructor followed a pre-written protocol (outlined in table 2, p. 52).
Deviations from intended interventions	Serious	Deviations from the intended intervention may arise from systematic differences between the yoga intervention and comparison groups (e.g. participants expectation of treatment and non-specific treatment effect).
Missing data	Serious	<p>Administrative error resulted in proportions of missing data. "Diagnostic information was only available for <math>n = 391</math> (72 % of the sample) due to clinical constraints (i.e. clinician was asked to skip diagnostic interview due to clinical acuity, etc.)" (p. 52, see Table 3). Thus, data or records were lost.</p> <p>They did not obtain data of their primary outcome (the Positive and Negative Affect Schedule; PANAS) amongst their comparison group.</p>
Measurement of outcomes	Serious	<p>The outcome assessors (in this case participant-reported outcomes) were aware of the intervention received.</p> <p>Lack of blinding might have influenced participants self-assessment.</p>
Selective reporting	Serious	Outcome reporting bias occurred since the study measured multiple outcomes, yet reported only those that were significant, rather than insignificant or unfavourable (Song et al., 2010). See p. 54: "A first mixed design MANCOVA (covarying propensity scores) examining changes in

		depression and anxiety symptoms during treatment did not reveal a significant Time x Yoga interaction, $p > .05$ . In other words, individuals who attended the yoga session did not experience differential improvements in depression/anxiety symptoms compared to individuals who did not attend the yoga session.”
Overall assessment	Serious	

## Study 2: Falsafi (2016)

### *Risk of bias*

Bias	HSP judgement	Support for judgement
Confounding bias	Serious	Did not control for confounding variables (e.g. concomitant treatment). For example, a total of 15 (22.38 %) participants stated that they received therapy during the course of the study which was not controlled for in subsequent analyses. Furthermore, interaction with the group leader and journaling may be confounding variables.
Selection of participants into the study	Moderate	A computer number random generator was utilised. Concerns remain as the random assessments were stratified by gender, and that randomisation occurred within the feasible timeframe of the participants schedules.
Classification of intervention	Low	A certified yoga instructor with training in trauma-sensitive yoga, psychiatric clinical specialist and certified holistic nurse instructed the interventions. Yoga intervention was clearly defined (p. 488).
Deviations from intended interventions	Serious	Deviations from the intended intervention may arise from systematic differences between the yoga intervention and comparison groups (e.g. participants expectation of treatment and non-specific treatment effect). Intervention and comparison groups were performed by the same instructor, indicating allegiance bias.
Missing data	Moderate	<p>Provided information regarding missing participants:</p> <p>“During the course of the study, 17 (20.24 %) students left the study for various reasons. Four students left after the first session. Three students started working after the study started, and the working hours interfered with the training schedules. Two students felt too overwhelmed with schoolwork, two students left the university, and one student had a car accident. Five students did not complete the follow-up session. The entire data package of any student who did not complete all 4 data collection sessions was excluded from consideration for data analyses. Out of 84 students who participated in the study, 67 (79.76 %) students completed the entire study.” (p. 488).</p>

Measurement of outcomes	Serious	<p>The outcome assessors (in this case participant-reported outcomes) were aware of the intervention received.</p> <p>Lack of blinding might have influenced participants self-assessment.</p> <p>Recall bias; used the same questionnaire at admission and discharge.</p>
Selective reporting	Low	No reason to suspect selective reporting.
Overall assessment	Serious	

### Study 3: Gabriel et al. (2018)

#### *Risk of bias*

Bias	HSP judgement	Support for judgement
Confounding bias	Moderate	Applied a propensity score based on potential baseline confounders. Controlled for baseline symptom severity, demographic characteristics, prior yoga experience and concomitant treatment.
Selection of participants into the study	Serious	<p>No random sequence generation due to study design: non-randomised controlled study, allocation based on self-selection (volunteers).</p> <p>No allocation concealment, allocation based on self-selection (volunteers). "Subjects participated in either condition based on patient preference" (p. 2)</p>
Classification of intervention	Low	A certified <i>kundalini</i> yoga instructor and licensed social worker instructed the intervention. Yoga intervention was clearly defined (p. 2).
Deviations from intended interventions	Serious	Deviations from the intended intervention may arise from systematic differences between the yoga intervention and comparison groups (e.g. participants expectation of treatment and non-specific treatment effect). Intervention and comparison groups were performed by the same instructor, indicating allegiance bias.
Missing data	Moderate	Administrative error resulted in proportions of missing data. "Due to administrative issues, the control group did not receive the BDI-II and BAI instrument measures, and the STAI, BDI and BAI were not administered to everyone in the Kundalini Yoga Intervention" (p. 6). Thus, data or records were lost. Nevertheless, missing data were accommodated with full information maximum likelihood information.

Measurement of outcomes	Serious	<p>The outcome assessors (in this case participant-reported outcomes) were aware of the intervention received.</p> <p>Lack of blinding might have influenced participants self-assessment.</p> <p>Recall bias; used the same questionnaire at admission and discharge.</p>
Selective reporting	Serious	Only significant outcome variables path coefficients were reported.
Overall assessment	Serious	

#### Study 4: Toschi et al. (2017)

##### *Risk of bias assessments*

Bias	HSP judgement	Support for judgement
Confounding bias	Serious	Did not control for confounding variables (e.g. concomitant treatment). They state that “even though all patients were stable and under the same therapy for at least 6 months before being allocated to the groups, the level of depression makes the groups clinically different at the beginning of the study” (p. 78), which may have influenced the results.
Selection of participants into the study	Serious	No random sequence generation due to study design: non-randomised controlled study. “We selected forty-six patients with a primary diagnosis of anxiety and/or mood disorders recruited (Doria et al., 2015) from the Department of Mental Health and Neurosciences of the Fatebenefratelli and Ophthalmic Hospital” (p. 75).
Classification of intervention	Low	Followed a predefined treatment programme manual (SKY).
Deviations from intended interventions	Serious	Deviations from the intended intervention may arise from systematic differences between the yoga intervention and comparison groups (e.g. participants expectation of treatment and non-specific treatment effect).
Missing data	Moderate	<p>No details on missing participants.</p> <p>Missing reporting of data; means and standard deviations.</p>
Measurement of outcomes	Serious	<p>The outcome assessors (in this case participant-reported outcomes) were aware of the intervention received.</p> <p>Lack of blinding might have influenced participants self-assessment. Although the risk of bias assessment concerns the continuous measures in the included studies, it is worth mentioning</p>

		<p>that the CAC outcome measure is considered objective and unaffected by intervention status, thus low risk of bias.</p> <p>Recall bias; used the same questionnaire at admission and discharge.</p>
Selective reporting	Low	No reason to suspect selective reporting. Provided a pre-registered protocol (clinical trial identification: NCT02828072).
Overall assessment	Serious	