



The relationship between repetitive negative thinking, sleep disturbance, and subjective fatigue in women with Generalized Anxiety Disorder

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Objectives. Fatigue is a prominent symptom of Generalized Anxiety Disorder (GAD). However, the pathways contributing to elevated fatigue in GAD are poorly understood. Sleep disturbance, also prominent in GAD, only partially explains elevated fatigue in GAD. Repetitive negative thinking (RNT) is a cognitive feature of both GAD and sleep disturbance, and RNT has recently also been associated with elevated fatigue. Therefore, this study assessed whether elevated fatigue in GAD is accounted for by a combination of sleep quality and RNT.

Design. Between-group, correlational design in 64 primarily university-educated women with and without a GAD diagnosis.

Methods. Women completed self-report questionnaires assessing RNT experienced in the past few days, previous night's sleep quality, and current physical and mental fatigue. Hierarchical linear regressions were conducted to assess whether the relationship between GAD status and fatigue is accounted for by RNT and sleep quality.

Results. Women with GAD reported lower sleep quality, and higher RNT and physical and mental fatigue, compared to women without GAD. Sleep quality partly accounted for group differences in both types of fatigue (β 's > -0.4), whereas RNT fully accounted for group differences in both types of fatigue (β 's > 0.29). The relationship between RNT and both types of fatigue was fully accounted for by sleep quality (β 's > -0.39).

Conclusions. These findings indicate that heightened RNT amongst women with GAD may be associated with elevated physical and mental fatigue via its detrimental effects on sleep quality. Interventions that reduce RNT may help to alleviate fatigue symptoms in women with GAD.

Practitioner points

- Women with Generalized Anxiety Disorder (GAD) have elevated fatigue and repetitive negative thinking (RNT), and poorer self-reported sleep quality, relative to women without GAD.

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- Whereas sleep quality only partially accounts for elevated fatigue in GAD, RNT fully accounts for elevated fatigue, and the relationship between RNT and fatigue is fully accounted for by sleep quality.
- These findings provide novel evidence that women with GAD may have elevated fatigue because of the detrimental effects of RNT on sleep.
- These findings suggest that targeting RNT in treatment for GAD may help to reduce fatigue in GAD, by improving sleep quality.

Subjective fatigue is broadly characterized as a multidimensional state of energy depletion, involving difficulty initiating or sustaining voluntary physical or cognitive activities (Chaudhuri & Behan, 2004), and is a prominent feature of multiple psychiatric conditions, particularly anxiety disorders, such as Generalized Anxiety Disorder (GAD; McCallum et al., 2019). The mechanisms contributing to elevated fatigue in anxiety disorders are ill-defined, although one likely candidate is sleep disturbance (poor subjective sleep quality and altered sleep characteristics, such as sleep duration), which frequently co-occurs with anxiety (Cox & Olatunji, 2020). Indeed, poorer self-reported sleep quality, but not sleep characteristics (e.g., sleep duration or onset latency), is associated with elevated fatigue in healthy people, people with psychosis, and people with insomnia (Harris, Carmona, Moss, & Carney, 2021; Lavidor, Weller, & Babkoff, 2003; Waters, Naik, & Rock, 2013). However, self-reported sleep quality only partially accounts for elevated fatigue in people with anxiety disorders, including GAD (McCallum et al., 2019), suggesting the presence of additional, yet to be identified, causes of fatigue in anxiety disorders.

Beyond sleep disturbance, another candidate mechanism that may contribute to elevated fatigue in anxiety disorders is repetitive negative thinking (RNT). RNT is a cognitive process, encompassing worry and rumination, that involves repetitive and negative thoughts about oneself and the world, which are often abstract, intrusive, and difficult to control (Ehring & Watkins, 2008). Although rumination and worry may differ in content and temporal orientation (e.g., past vs. future-oriented, respectively), the underlying process of each is thought to be common, with 84% of the shared variance between rumination- and worry-specific questionnaires being accounted for by a single RNT-specific questionnaire (Spinhoven, Drost, van Hemert, & Penninx, 2015). RNT is a key cognitive feature of anxiety and depressive disorders (Ehring & Watkins, 2008; Wahl et al., 2019), and there is a well-established bidirectional relationship between RNT and sleep disturbance in clinical and non-clinical populations (Carney, Harris, Moss, & Edinger, 2010; Clancy, Prestwich, Caperton, Tsipa, & O'Connor, 2020; Guastella & Moulds, 2007; Thielsch et al., 2015). By comparison, much less is known about the relationship between RNT and fatigue. Some evidence suggests that fatigue is associated with RNT-like processes (e.g., rumination, catastrophizing, and dysfunctional beliefs) in conditions such as insomnia, major depressive disorder, and multiple sclerosis (Carney, Moss, Lachowski, & Atwood, 2014; Hare, Crangle, Carney, & Hart, 2019; Harris et al., 2021). Likewise, rumination and worry predicted higher fatigue in the general population (Thorsteinsson, Brown, & Owens, 2019) and the workforce (Andrea et al., 2004; Querstret & Copley, 2012), with sleep disturbance fully or partially mediating these effects, respectively. Combined, this suggests that, alongside sleep disturbance, RNT may be a key mechanism contributing to heightened fatigue in anxiety disorders, although this possibility is yet to be assessed.

In this study, we examined whether RNT and self-reported sleep quality together account for elevated physical and mental fatigue in women with GAD, versus women without GAD. The participants reported on RNT in relation to a recent stressful event experienced in the past few days, self-reported sleep quality from the preceding night, and

current levels of physical and mental fatigue. This enabled us to speculate as to the temporal relationship between RNT, sleep quality, and subsequent fatigue levels. This is in contrast to previous cross-sectional studies on this topic, which assessed trait RNT (one's general tendency to engage in RNT), and aggregated sleep disturbance and fatigue (e.g., that experienced over the past month). The following hypotheses were made:

1. Compared to women without GAD, women with GAD would have higher levels of physical and mental fatigue (Li, Lloyd, & Graham, 2020), and RNT (Li, Denson, & Graham, 2020; Wahl et al., 2019). Note that, in previous analyses of the sample examined in this study, it was demonstrated and reported that women with GAD reported poorer sleep quality relative to non-anxious women (Li, Lloyd, & Graham, 2021).
2. Higher RNT and lower sleep quality would be related to elevated physical and mental fatigue across the whole sample (Carney et al., 2010; Lavidor et al., 2003; Thorsteinsson et al., 2019).
3. Lower sleep quality would only partially account for group differences in physical and mental fatigue (McCallum et al., 2019).
4. RNT and sleep quality together would fully account for group differences in physical and mental fatigue.

Methods

Participants

This study was conducted with the understanding and written consent of each participant. All procedures were carried out in accordance with the Declaration of Helsinki and approved by the UNSW Human Research Ethics Committee (approval number: HC180455). The participants were recruited through university advertisements and a public online participation system, targeting women with and without a diagnosis of GAD, to take part in a study with multiple aims. In addition to examining the relationship between RNT and fatigue, the study examined sleep disturbance over the menstrual cycle. The results for this latter aim were reported previously (Li et al., 2021). The participants received course credit or \$AUD20 per hour for participation. Given the multiple aims of the study, exclusion criteria included premenstrual dysphoric disorder, irregular menstrual cycles, medically diagnosed fertility problems (e.g., endometriosis, polycystic ovary syndrome), endocrine disorders, and hormonal contraceptive use, pregnancy, or breastfeeding within the last 3 months. Before the study, all the participants were screened for GAD using the Generalised Anxiety Disorder-7 (GAD-7 [Spitzer, Kroenke, Williams, & Löwe, 2006]). At the start of the study, the presence or absence of a GAD diagnosis was confirmed using the GAD module of the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders 5 (SCID-5 [First, Williams, Karg, & Spitzer, 2016]). After excluding four participants for irregular menstrual cycles, the final sample consisted of 32 women with GAD, and 32 non-anxious women. Based on past studies examining the relationship between RNT and fatigue, large effect sizes were expected (Carney et al., 2010; Querstret & Cropley, 2012; Thorsteinsson et al., 2019). A power analysis (G*Power) showed that a total sample size of 64 was adequately powered ($1 - \beta = 0.8$) to detect medium to large effect sizes ($f^2 = .19$, $\alpha = .05$) in regression models using up to three predictors.

Measures

Generalised Anxiety Disorder-7 (GAD-7 [Spitzer et al., 2006])

The GAD-7 is a 7-item self-report measure of GAD symptoms experienced in the past 2 weeks. Each item is scored on a Likert scale from 0 (not at all) to 3 (nearly every day). Total scores range from 0 to 21, with a total score of 10 or greater indicating a probable GAD diagnosis. The GAD-7 is sensitive in detecting severity of GAD symptoms (Spitzer et al., 2006) and showed excellent internal consistency in this study (Cronbach's $\alpha = .91$).

Repetitive thinking questionnaire-10 (RTQ-10 [McEvoy, Mahoney, & Moulds, 2010])

The RTQ-10 is a 10-item self-report measure of RNT in relation to a recent distressing event. In this study, the participants wrote a brief description of a situation about which they felt upset or distressed in the last few days. The participants then rated statements regarding repetitive thoughts about themselves and their experiences following the distressing situation, on a scale from 1 (not true at all) to 5 (very true) (e.g., 'I thought about the situation all the time'). Higher total scores on the RTQ-10 indicate higher RNT. The RTQ-10 has good construct and convergent validity (Mahoney, McEvoy, & Moulds, 2012; McEvoy et al., 2010). The RTQ-10 showed excellent internal consistency in this study (Cronbach's $\alpha = .94$).

Sleep diary

The sleep diary was adapted from the Consensus Sleep Diary (Carney et al., 2012), a self-report measure of participants' sleep experience in the previous night. The participants reported sleep characteristics (e.g., time of getting to sleep and waking, awakenings during the night), and perceived sleep quality on a Likert scale, with options being 1 (very poor), 2 (poor), 3 (fair), 4 (good), and 5 (very good). The sleep diary is considered the gold-standard for measuring subjective sleep, and can differentiate between good sleepers and individuals with insomnia (Carney et al., 2012). It was previously reported that in this sample of women, groups only differed on the sleep quality index, and not any sleep characteristics (Li et al., 2021). Therefore, in this study, we focused exclusively on sleep quality.

Fatigue and Energy Scale (FES [Keech et al., 2015])

The FES is a 6-item self-report measure of fatigue. Three items measure physical fatigue ('exhaustion', 'heaviness in the limbs', 'drained of physical energy/low in vitality') and three items measure mental fatigue ('brain fog', 'difficulties with memory or concentration/disoriented/wired', 'drained of mental energy'). The participants were instructed to indicate 'how much of each symptom you are feeling right now' on a scale from 0 (no fatigue) to 10 (absolute maximum fatigue). Physical fatigue and mental fatigue scores were calculated by averaging the three items within each dimension. The FES has good construct and convergent validity (Keech et al., 2015). The FES showed excellent internal consistency in this study (Cronbach's $\alpha = .94$).

Procedure

The participants responding to study advertisements were screened for eligibility and possible GAD status via the GAD-7. Eligible participants attended an in-person session in which they were administered the SCID-5, then provided a saliva sample (to test for hormone levels for the separate study aim), and then completed online surveys containing the RTQ-10, Sleep Diary, and the FES. This was followed by completion of other questionnaires and a cognitive task, the data from which are not reported here. Note that, to meet the broader study aims, the participants completed two in-person sessions (both of which were identical, except the administration of the SCID-5 only took place in the first session), spaced 2 weeks apart, that were scheduled according to their menstrual phase, counterbalanced between the participants. The data reported here were obtained from the first session only.

Data analysis

All analyses were conducted using IBM SPSS (v25). Demographic variables, GAD symptom severity, RNT, fatigue, and sleep quality were compared between diagnostic groups via Fisher's Exact Test or independent samples *t*-tests. Participants' descriptions of distressing situations in the RTQ-10 were coded according to theme (school/work, interpersonal relationships, health, world issues, other/minor matters). The distributions of these themes were compared between diagnostic groups using chi-square analyses.

Bivariate correlations tested associations between RNT, fatigue, and sleep quality. To investigate the contribution of RNT and sleep quality in accounting for fatigue, two sets of hierarchical linear regressions were conducted, with physical and mental fatigue as the dependent variables in each set. In the first set, to assess whether sleep quality on its own accounts for group differences in fatigue, GAD status was entered in step 1 (dummy variables: non-anxious = 0, GAD = 1), and grand mean-centred sleep quality was entered in step 2. In the second set, to assess whether RNT and sleep quality together account for group differences in fatigue, GAD status was entered in step 1, grand mean-centred RTQ-10 total score was entered in step 2, and grand mean-centred sleep quality was entered in step 3. Note that outcomes remained the same when sleep quality was dummy-coded as a categorical variable (results not reported).

Results

Sample characteristics

Sample characteristics are summarized in Table 1. Women with and without GAD did not differ on age, education level, ethnic representation, marital status, or employment status (note that information on education level, employment, and marital status was missing for one participant with GAD). Compared to women without GAD, women with GAD reported significantly greater GAD symptom severity ($t = -7.51, p < .0001$, Cohen's $d = -1.88$), physical fatigue ($t = -3.69, p < .0001$, Cohen's $d = -.92$), mental fatigue ($t = -3.95, p < .0001$, Cohen's $d = -.99$), RTQ-10 ($t = -6.84, p < .0001$, Cohen's $d = -1.71$), and poorer sleep quality ($t = 3.48, p = .001$, Cohen's $d = .87$).

There were no significant group differences in the themes of the distressing situations described in the RTQ-10 ($\chi^2 = 1.24, p = 0.87$; Table 1). The most common category was school/work, followed by relationships, other/minor matters (e.g., moving to a new environment, being late), health, and world issues.

Table 1. Sample characteristics

	Non-anxious women		Women with GAD		p-value
	n	%	n	%	
Education level					.56
High school	28	87.5	28	87.5	
Graduate Diploma	1	3.1	1	3.1	
Bachelor's	3	9.4	1	3.1	
Master's degree	0	0	1	3.1	
Ethnic representation					.73
Asian	22	68.8	20	62.5	
Caucasian	8	25	8	25	
Other	1	6.3	4	9.4	
Marital status					.37
Divorced/separated	0	0	1	3.1	
Married	0	0	1	3.1	
Never married	32	100	29	90.6	
Employment					.37
Student	21	65.6	19	59.4	
Full time	2	6.3	0	0	
Part time	9	28.1	11	34.4	
Self-employed	0	0	1	3.1	
RTQ-10 situation theme					.87
Health	2	6.3	2	6.3	
Relationship	9	28.1	6	18.8	
School/work	12	37.5	16	50	
World issues	1	3.1	1	3.1	
Other/Minor matters	8	25	7	21.9	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	p-value
Age	19.3	1.5	19.7	3.6	.61
Sleep quality	3.8	.9	3.1	.9	.001*
GAD-7	3.8	3.9	11.5	4.2	<.0001**
FES physical fatigue	3.3	1.8	5.1	2.0	<.0001**
FES mental fatigue	3.4	1.9	5.5	2.4	<.0001**
RTQ-10	21.0	10.0	36.7	8.4	<.0001**

Note. FES = Fatigue and Energy Scale; GAD-7 = Generalised Anxiety Disorder-7; RTQ-10 = Repetitive Thinking Questionnaire-10.

p* < .05; *p* < .001.

Correlations

GAD status, GAD symptom severity, sleep quality, RTQ-10, and physical and mental fatigue, were all highly correlated with one another (Table 2).

Hierarchical linear regressions

The first set of regressions (Table 3) showed that GAD status remained significantly associated with physical and mental fatigue after accounting for sleep quality. Sleep

Table 2. Bivariate correlations

	GAD status	Sleep quality	FES physical fatigue	FES mental fatigue	RTQ-10
Sleep quality	-.40**				
FES physical fatigue	.42**	-.53**			
FES mental fatigue	.45**	-.53**	.80**		
RTQ-10	.66**	-.38*	.47**	.46**	
GAD-7	.69**	-.45**	.53**	.62**	.69**

Note. FES, Fatigue and Energy Scale; GAD Status = non-anxious (0) GAD (1); GAD-7, Generalised Anxiety Disorder-7; RTQ-10, Repetitive Thinking Questionnaire-10.

**Significant correlation $p < .0001$.

*Significant correlation $p < .005$.

Table 3. Linear regression models of the relationship between sleep quality and physical and mental fatigue

Step	Variable	R ²	Adjusted R ²	ΔR^2	B	SE B	β	t	p	95% CI
<i>Model 1. Physical fatigue</i>										
1 ^a	GAD status ^b	.18	.17	.18	1.76	.48	.42	3.69	<.0001	.81, 2.71
2 ^a	GAD status ^b	.34	.32	.16 ^c	1.04	.47	.25	2.20	.03	.09, 1.99
	Sleep quality ^b				-.92	.25	-.43	-3.77	<.0001	-1.41, -.43
<i>Model 2. Mental fatigue</i>										
1 ^a	GAD Status ^b	.20	.19	.20	2.09	.53	.45	3.95	<.0001	1.03, 3.15
2 ^a	GAD Status ^b	.35	.33	.15 ^c	1.31	.53	.28	2.48	.02	.25, 2.37
	Sleep quality ^b				-1.01	.27	-.42	-3.68	.001	-1.55, -.46

Note. GAD Status = non-anxious (0) GAD (1).

^aSignificant model.; ^bSignificant variable.; ^cSignificant ΔR^2 .

quality was significantly associated with physical and mental fatigue after accounting for GAD status, and its inclusion in the models accounted for an additional 15% of variance in physical fatigue, and 14% of variance in mental fatigue. Moreover, inclusion of sleep quality reduced the relationship of GAD status to physical and mental fatigue, as indicated by a reduction in beta values, suggesting that sleep quality partially accounted for the relationship between GAD status and fatigue.

The second set of regressions (Table 4) showed that after accounting for GAD status, RTQ-10 was significantly associated with physical fatigue, and associated with mental fatigue in a nonsignificant trend ($p = .05$). In both models, GAD status was no longer significantly associated with fatigue after accounting for RTQ-10. This suggests that the relationship between GAD status and physical and mental fatigue was fully accounted for by RTQ-10. Sleep quality, when added to the models in step 3, was significantly associated with physical and mental fatigue. In both models, RTQ-10 was no longer significantly associated with fatigue after accounting for sleep quality, suggesting that the relationship between RTQ-10 and physical and mental fatigue was fully accounted for by sleep quality. In both models, inclusion of sleep quality accounted for an additional 12% of variance, with the full models accounting for 34% of variance in physical and mental fatigue.

Table 4. Linear regression models of the relationship between RTQ-10, sleep quality, and physical and mental fatigue

Step	Variable	R ²	Adjusted R ²	Δ R ²	B	SE B	β	t	p	95% CI
<i>Model 1. Physical fatigue</i>										
1 ^a	GAD Status ^b	.18	.17	.18	1.76	.48	.42	3.69	<.0001	.81, 2.71
2 ^a	GAD status	.24	.22	.06 ^c	.86	.61	.21	1.41	.17	-.36, 2.09
	RTQ-10 ^b				.06	.03	.33	2.24	.03	.006, .11
3 ^a	GAD status	.37	.34	.13 ^c	.41	.58	.10	.71	.48	-.75, 1.56
	RTQ-10				.04	.02	.25	1.84	.07	-.004, .09
	Sleep quality ^b				-.85	.24	-.49		.001	-1.34, -.36
<i>Model 2. Mental fatigue</i>										
1 ^a	GAD status ^b	.20	.19	.20	2.09	.53	.45	3.95	<.0001	1.03, 3.15
2 ^a	GAD status	.25	.22	.05	1.21	.69	.26	1.76	.08	-.17, 2.58
	RTQ-10				.06	.03	.29	1.97	.05	-.001, .11
3 ^a	GAD status	.37	.34	.12 ^c	.71	.65	.15	1.09	.28	-.59, 2.01
	RTQ-10				.04	.03	.21	1.55	.13	-.01, .10
	Sleep quality ^b				-.94	.27	-.39	-3.42	.001	-1.48, -.3

Note. GAD status = non-anxious (0) GAD (1); RTQ-10 = Repetitive Thinking Questionnaire-10.

^aSignificant model.; ^bSignificant variable.; ^cSignificant ΔR².

Discussion

This study investigated whether group differences in physical and mental fatigue between women with and without GAD are fully accounted for by a combination of RNT and sleep quality. As hypothesized and consistent with previous findings (Cox & Olatunji, 2020; Li, Lloyd, et al., 2020; McCallum et al., 2019), women with GAD reported higher physical and mental fatigue, RNT, and poorer sleep quality than women without GAD. Consistent with McCallum et al. (2019), sleep quality alone only partially accounted for group differences in fatigue. In contrast, the novel finding was that RNT fully accounted for group differences in physical and mental fatigue. RNT did not remain significantly associated with fatigue after taking sleep quality into account, and sleep quality accounted for the largest variance in physical and mental fatigue of the examined variables. Together, these findings suggest that elevated fatigue in GAD is explained by heightened RNT, and the relationship between heightened RNT and fatigue is accounted for by poor sleep quality. These findings are in line with prior cross-sectional research demonstrating that sleep quality fully accounts for the relationship between rumination and fatigue in the general population (Thorsteinsson et al., 2019), and extends these findings to people with anxiety disorders.

Women with GAD may have experienced physical and mental fatigue because their heightened RNT in relation to a recent stressor led to poor perceived sleep quality, with ensuing consequences for fatigue. This explanation is consistent with the temporal order in which these factors were assessed in this study, where the participants reported on RNT experienced in the past few days, perceived sleep quality during the night before the study, and current levels of fatigue. However, it is possible that the participants may not have responded to items in reference to the instructed time periods, or that their responses were influenced by recall biases. Moreover, given that RNT has a bidirectional relationship with sleep quality (Thielsch et al., 2015), it is likely that women with GAD also had poorer sleep quality on nights preceding the study, which likely contributed to their

heightened RNT. This raises questions about whether fatigue has a similar bidirectional relationship with RNT and sleep quality. That is, it is possible that feelings of fatigue may increase RNT (e.g., about the debilitating consequences of fatigue), which would lead to poor sleep quality the subsequent night, and further increase fatigue the next day. As such, while this study was able to provide some information on a possible temporal order of the relationship between RNT, sleep quality, and fatigue, our understanding of how these factors interact over longer periods of time is incomplete.

A related consideration is the extent to which our study captured state fatigue and RNT. It has previously been shown that 27% of the variance in present moment fatigue is attributable to an occasion-specific (i.e., state) component, whereas 71% is attributable to a trait (i.e., relatively static) component (Hoofs, Jansen, Jansen, & Kant, 2017). Moreover, although one's tendency to engage in RNT is stable over time, RNT can be experimentally induced, demonstrating a state-component (Watkins & Roberts, 2020). As such, although in this study, the participants reported on RNT in the days preceding the study, and on current fatigue levels, it is almost certain that these measures captured both state and trait variance in fatigue and RNT. Thus, it is possible that the observed relationships emerged because of underlying relationships between trait RNT and trait fatigue. Although it is still of theoretical and practical interest to understand these relationships at a trait level, it is unclear the extent to which within-person variance in RNT and sleep quality contributes to within-person variance in fatigue. To address these knowledge gaps, future studies in this area could use ecological momentary assessment (EMA) of RNT, fatigue, and sleep, over an extended duration, to determine if within-person fluctuations in fatigue are predicted by within-person fluctuations in RNT and sleep quality, in addition to determining whether present moment RNT predicts next moment fatigue, and vice versa. This analytical approach has been previously used to study relationships between sleep and RNT, which, as noted, have bidirectional interactions (Thielsch et al., 2015). EMA has also been used to show that prior night's sleep predicts next day fatigue (Depasquale et al., 2019; Harris et al., 2021), and Harris et al. (2021) showed that this relationship was partly mediated by dysfunctional beliefs and rumination about sleep (assessed as a trait variable) in a sample of people with and without insomnia. However, the relationship between within-person fluctuations in RNT (assessed as a state variable), sleep quality, and fatigue, and the bidirectionality of these relationships, remains to be assessed in both healthy and anxious samples.

Our analyses revealed no significant group differences in the themes of distressing situations focused on during RNT that could plausibly account for heightened RNT in women with GAD. This indicates that irrespective of the *content* of thoughts, it is the abstract, over-general, difficult to control, and intrusive thought *process* of RNT (Ehring & Watkins, 2008) which contributes to heightened fatigue in women with GAD. Most prior studies examining the relationship between RNT-like processes and fatigue have measured fatigue- or sleep-focused RNT (e.g., thinking about fatigue and sleep symptoms in a negative, repetitive manner; [Carney et al., 2014; Querstret & Cropley, 2012]), or have not assessed the content of RNT (Andrea et al., 2004; Thorsteinsson et al., 2019; Young, Reardon, & Azam, 2008). One study reported that fatigue catastrophizing, but not general rumination, mediated the relationship between insomnia and fatigue (Hare et al., 2019). Notably, in this study, no participants identified fatigue or sleep as the focus of their RNT. This could partially be due to the RTQ-10 questionnaire used in this study to assess RNT, which asked the participants to report on a specific situation. Indeed, it is possible that people who reported higher RNT in relation to a stressful event also experienced higher RNT regarding fatigue and/or sleep disturbance, and this was not captured in this study. As

such, an avenue for further investigation is to identify whether the content of RNT, specifically distinguishing between that focused on fatigue and sleep-related concerns, versus non-fatigue and sleep-related concerns, is differentially related to fatigue outcomes.

Levels of mental and physical fatigue in women with GAD in this study were comparable to the levels of excessive and debilitating fatigue reported by patients with chronic fatigue syndrome in other studies (Cvejic et al., 2017; Keech et al., 2015). The prevalence and severity of fatigue in more widely representative groups of people with GAD (see 'Limitations') remain to be assessed in larger studies. Irrespective, these findings are consistent with findings from the general community indicating that fatigue is a problematic symptom associated with GAD (McCallum et al., 2019) that could benefit from being directly addressed in treatment settings. However, the impact of first-line treatments for GAD, such as cognitive behavioural therapy, on fatigue is rarely assessed and is not the focus of treatment, perhaps because fatigue is considered an ancillary symptom of GAD. Based on our study's findings that the process, and not the content, of RNT contributes to heightened fatigue in GAD, directly targeting the process of RNT may help to reduce fatigue in GAD, via treatments such as rumination-focussed cognitive behavioural therapy (RF-CBT), which reduces RNT by identifying its triggers, and replacing RNT with adaptive cognitive processes (e.g., mindfulness, acceptance, concrete thinking; [Watkins et al., 2007]). RF-CBT has shown promise in reducing relapse in treatment-refractory depression (Watkins & Roberts, 2020). It would be worthwhile to determine whether RF-CBT is also effective in reducing fatigue severity in people with anxiety, and indeed, other mental health conditions in which fatigue is a prominent symptom.

Limitations

One limitation of this study is that causality cannot be established. Although our procedure enabled us to speculate on the temporal order of relationships between RNT, sleep quality, and fatigue, future research should include repeated measurements of these factors longitudinally. In addition, RNT could be experimentally exacerbated at bedtime (Guastella & Moulds, 2007), or reduced (e.g., via novel cognitive training programmes [Roberts, Mostazir, Moberly, Watkins, & Adlam, 2021]) to identify the effects of up- or down-regulating RNT on subsequent sleep quality and fatigue.

In addition, this study did not assess depressive symptoms or stress. Because depression is highly comorbid with GAD, and is also associated with elevated RNT (Ehring & Watkins, 2008), and sleep disturbance and fatigue (Carney et al., 2014; McCallum et al., 2019), it is possible that between group differences in fatigue were influenced by comorbid depressive symptoms. Furthermore, examination of subjective stress (i.e., in relation to life events), which has a bidirectional relationship with fatigue (Doerr et al., 2015) could contribute to a greater understanding of the underlying pathways contributing to elevated fatigue in GAD. Nonetheless, we speculate that any impact of depression or stress on fatigue is likely mediated via RNT, as has been previously reported in the general population (Thorsteinsson et al., 2019).

In keeping with the prevailing literature on RNT and sleep, we focused on a subjective measure of sleep, and as group differences in self-reported sleep quality but not sleep characteristics were previously documented in this sample of participants (Li et al., 2021), only sleep quality was included in the present analyses. Combined, this suggests that the relationship between RNT and the appraisal of sleep quality, rather than quantitative aspects of sleep, may account for the relationship between GAD status and fatigue. This is

commensurate with findings that the relationship between RNT and sleep quality is stronger when sleep is measured via self-report as opposed to actigraphy (Clancy et al., 2020). However, our lack of objective measures of sleep characteristics and dynamics via actigraphy and polysomnography precludes strong conclusions about this issue, as it is possible that heightened RNT in women with GAD may be associated with changes in sleep architecture that were not reflected in self-reports on sleep characteristics.

Another limitation is that our study sample consisted only of female participants, and primarily full-time university students, and is therefore not representative of all treatment-seeking individuals and non-anxious individuals. While future research could examine RNT, sleep quality, and fatigue in non-student samples to improve generalizability of results, it is worthwhile to study these factors in women. This is because women have higher levels of RNT (Nolen-Hoeksema & Aldao, 2011), subjective sleep disturbance (Mong & Cusmano, 2016), and fatigue (Engberg, Segerstedt, Waller, Wennberg, & Eliasson, 2017) than men. Women are also twice as likely than men to meet criteria for GAD (McLean, Asnaani, Litz, & Hofmann, 2011). Therefore, it is important to identify how to manage fatigue in this highly susceptible population, although consideration of male participants in future studies is required to determine whether there are sex differences in the factors accounting for fatigue in anxious populations.

Conclusion

Our study is the first to show that RNT is a cognitive factor contributing to heightened fatigue in women with GAD. We found that elevated RNT and sleep quality together account for heightened fatigue in GAD. These findings provide a basis for future research investigating potential cognitive mechanisms underlying fatigue in anxiety disorders and have practical implications for our understanding of how to reduce heightened fatigue in GAD.

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Conflict of interest

All authors declare no conflict of interest.

Author contribution

Phoebe Leung: Formal analysis (equal); Writing – original draft (equal); Writing – review & editing (equal). **Sophie Li:** Conceptualization (equal); Data curation (equal); Funding acquisition (equal); Investigation (equal); Methodology (equal); Project administration (equal); Writing – review & editing (equal). **Bronwyn Graham:** Conceptualization (equal); Formal analysis (equal); Funding acquisition (equal); Methodology (equal); Supervision (equal); Writing – original draft (equal); Writing – review & editing (equal).

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

- Andrea, H., Beurskens, A. J. H. M., Kant, I. J., Davey, G. C. L., Field, A. P., & van Schayck, C. P. (2004). The relation between pathological worrying and fatigue in a working population. *Journal of Psychosomatic Research*, *57*, 399–407. <https://doi.org/10.1016/j.jpsychores.2003.09.013>
- Carney, C. E., Buysse, D. J., Ancoli-Israel, S., Edinger, J. D., Krystal, A. D., Lichstein, K. L., & Morin, C. M. (2012). The consensus sleep diary: Standardizing prospective sleep self-monitoring. *Sleep*, *35*, 287–302. <https://doi.org/10.5665/sleep.1642>
- Carney, C. E., Harris, A. L., Moss, T. G., & Edinger, J. D. (2010). Distinguishing rumination from worry in clinical insomnia. *Behaviour Research and Therapy*, *48*, 540–546. <https://doi.org/10.1016/j.brat.2010.03.004>
- Carney, C. E., Moss, T. G., Lachowski, A. M., & Atwood, M. E. (2014). Understanding mental and physical fatigue complaints in those with depression and insomnia. *Behavioral Sleep Medicine*, *12*, 272–289. <https://doi.org/10.1080/15402002.2013.801345>
- Chaudhuri, A., & Behan, P. O. (2004). Fatigue in neurological disorders. *The Lancet*, *363*, 978–988. [https://doi.org/10.1016/S0140-6736\(04\)15794-2](https://doi.org/10.1016/S0140-6736(04)15794-2)
- Clancy, F., Prestwich, A., Caperon, L., Tsipa, A., & O'Connor, D. B. (2020). The association between worry and rumination with sleep in non-clinical populations: A systematic review and meta-analysis. *Health Psychology Review*, *14*, 427–448. <https://doi.org/10.1080/17437199.2019.1700819>
- Cox, R. C., & Olatunji, B. O. (2020). Sleep in the anxiety-related disorders: A meta-analysis of subjective and objective research. *Sleep Medicine Reviews*, *51*, 101282. <https://doi.org/10.1016/j.smrv.2020.101282>
- Cvejic, E., Sandler, C. X., Keech, A., Barry, B. K., Lloyd, A. R., & Vollmer-Conna, U. (2017). Autonomic nervous system function, activity patterns, and sleep after physical or cognitive challenge in people with chronic fatigue syndrome. *Journal of Psychosomatic Research*, *103*, 91–94. <https://doi.org/10.1016/j.jpsychores.2017.10.010>
- Depasquale, N., Crain, T., Buxton, O. M., Zarit, S. H., Almeida, D. M., & Pruchno, R. (2019). Tonight's sleep predicts tomorrow's fatigue: A daily diary study of long-term care employees with nonwork caregiving roles. *Gerontologist*, *59*, 1065–1077. <https://doi.org/10.1093/geront/gny176>
- Doerr, J. M., Ditzen, B., Strahler, J., Linnemann, A., Ziemek, J., Skoluda, N., . . . Nater, U. M. (2015). Reciprocal relationship between acute stress and acute fatigue in everyday life in a sample of university students. *Biological Psychology*, *110*, 42–49. <https://doi.org/10.1016/j.biopsycho.2015.06.009>
- Ehring, T., & Watkins, E. R. (2008). Repetitive negative thinking as a transdiagnostic process. *International Journal of Cognitive Therapy*, *1*, 192–205. <https://doi.org/10.1680/ijct.2008.1.3.192>
- Engberg, I., Segerstedt, J., Waller, G., Wennberg, P., & Eliasson, M. (2017). Fatigue in the general population—associations to age, sex, socioeconomic status, physical activity, sitting time and self-rated health: the northern Sweden MONICA study 2014. *BMC Public Health*, *17*(654). <https://doi.org/10.1186/s12889-017-4623-y>
- First, M. B., Williams, J. B., Karg, R. S., & Spitzer, R. L. (2016). *Structured clinical interview for DSM-5 Disorders – Clinician Version*. Arlington, VA: APA Publishing.
- Guastella, A. J., & Moulds, M. L. (2007). The impact of rumination on sleep quality following a stressful life event. *Personality and Individual Differences*, *42*, 1151–1162. <https://doi.org/10.1016/j.paid.2006.04.028>

- Hare, C. J., Crangle, C. J., Carney, C. E., & Hart, T. (2019). Insomnia symptoms, subjective appraisals, and fatigue: A multiple mediation model. *Behavioral Sleep Medicine, 17*, 269–280. <https://doi.org/10.1080/15402002.2017.1342167>
- Harris, A. L., Carmona, N. E., Moss, T. G., & Carney, C. E. (2021). Testing the contiguity of the sleep and fatigue relationship: A daily diary study. *Sleep, 44*(5). <https://doi.org/10.1093/sleep/zsaa252>
- Hoofs, H., Jansen, N. W. H., Jansen, M. W. J., & Kant, I. J. (2017). The trait and occasion components of fatigue and their association with sickness absence. *Journal of Psychosomatic Research, 102*, 54–60. <https://doi.org/10.1016/j.jpsychores.2017.09.007>
- Keech, A., Sandler, C. X., Vollmer-Conna, U., Cvejic, E., Lloyd, A. R., & Barry, B. K. (2015). Capturing the post-exertional exacerbation of fatigue following physical and cognitive challenge in patients with chronic fatigue syndrome. *Journal of Psychosomatic Research, 79*, 537–549. <https://doi.org/10.1016/j.jpsychores.2015.08.008>
- Lavidor, M., Weller, A., & Babkoff, H. (2003). How sleep is related to fatigue. *British Journal of Health Psychology, 8*, 95–105. <https://doi.org/10.1348/135910703762879237>
- Li, S. H., Denson, T. F., & Graham, B. M. (2020). Women with generalized anxiety disorder show increased repetitive negative thinking during the luteal phase of the menstrual cycle. *Clinical Psychological Science, 8*, 1037–1045. <https://doi.org/10.1177/2167702620929635>
- Li, S. H., Lloyd, A. R., & Graham, B. M. (2020). Physical and mental fatigue across the menstrual cycle in women with and without generalised anxiety disorder. *Hormones and Behavior, 118*, 104667. <https://doi.org/10.1016/j.yhbeh.2019.104667>
- Li, S. H., Lloyd, A. R., & Graham, B. M. (2021). Subjective sleep quality and characteristics across the menstrual cycle in women with and without Generalized Anxiety Disorder. *Journal of Psychosomatic Research, 148*, 110570. <https://doi.org/10.1016/j.jpsychores.2021.110570>
- Mahoney, A. E. J., McEvoy, P. M., & Moulds, M. L. (2012). Psychometric properties of the Repetitive Thinking Questionnaire in a clinical sample. *Journal of Anxiety Disorders, 26*, 359–367. <https://doi.org/10.1016/j.janxdis.2011.12.003>
- McCallum, S. M., Batterham, P. J., Cleave, A. L., Sunderland, M., Carragher, N., & Kazan, D. (2019). Associations of fatigue and sleep disturbance with nine common mental disorders. *Journal of Psychosomatic Research, 123*, 109727. <https://doi.org/10.1016/j.jpsychores.2019.05.005>
- McEvoy, P. M., Mahoney, A. E. J., & Moulds, M. L. (2010). Are worry, rumination, and post-event processing one and the same? Development of the repetitive thinking questionnaire. *Journal of Anxiety Disorders, 24*, 509–519. <https://doi.org/10.1016/j.janxdis.2010.03.008>
- McLean, C. P., Asnaani, A., Litz, B. T., & Hofmann, S. G. (2011). Gender differences in anxiety disorders: Prevalence, course of illness, comorbidity and burden of illness. *Journal of Psychiatric Research, 45*, 1027–1035. <https://doi.org/10.1016/j.jpsychores.2011.03.006>
- Mong, J. A., & Cusmano, D. M. (2016). Sex differences in sleep: Impact of biological sex and sex steroids. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*, 20150110. <https://doi.org/10.1098/rstb.2015.0110>
- Nolen-Hoeksema, S., & Aldao, A. (2011). Gender and age differences in emotion regulation strategies and their relationship to depressive symptoms. *Personality and Individual Differences, 51*, 704–708. <https://doi.org/10.1016/j.paid.2011.06.012>
- Querstret, D., & Cropley, M. (2012). Exploring the relationship between work-related rumination, sleep quality, and work-related fatigue. *Journal of Occupational Health Psychology, 17*, 341–353. <https://doi.org/10.1037/a0028552>
- Roberts, H., Mostazir, M., Moberly, N. J., Watkins, E. R., & Adlam, A. L. (2021). Working memory updating training reduces state repetitive negative thinking: Proof-of-concept for a novel cognitive control training. *Behaviour Research and Therapy, 142*, 103871. <https://doi.org/10.1016/j.brat.2021.103871>
- Spinhoven, P., Drost, J., van Hemert, B., & Penninx, B. W. (2015). Common rather than unique aspects of repetitive negative thinking are related to depressive and anxiety disorders and symptoms. *Journal of Anxiety Disorders, 33*, 45–52. <https://doi.org/10.1016/j.janxdis.2015.05.001>

- Spitzer R. L., Kroenke K., Williams J. B. W., Löwe B. (2006). A Brief Measure for Assessing Generalized Anxiety Disorder. *Archives of Internal Medicine*, *166*(10), 1092. <http://dx.doi.org/10.1001/archinte.166.10.1092>
- Thielsch, C., Ehring, T., Nestler, S., Wolters, J., Kopei, I., Rist, F., ... Andor, T. (2015). Metacognitions, worry and sleep in everyday life: Studying bidirectional pathways using Ecological Momentary Assessment in GAD patients. *Journal of Anxiety Disorders*, *33*, 53–61. <https://doi.org/10.1016/j.janxdis.2015.04.007>
- Thorsteinsson, E. B., Brown, R. F., & Owens, M. T. (2019). Modeling the effects of stress, anxiety, and depression on rumination, sleep, and fatigue in a nonclinical sample. *Journal of Nervous and Mental Disease*, *207*, 355–359. <https://doi.org/10.1097/NMD.0000000000000973>
- Wahl, K., Ehring, T., Kley, H., Lieb, R., Meyer, A., Kordon, A., ... Schönfeld, S. (2019). Is repetitive negative thinking a transdiagnostic process? A comparison of key processes of RNT in depression, generalized anxiety disorder, obsessive-compulsive disorder, and community controls. *Journal of Behavior Therapy and Experimental Psychiatry*, *64*, 45–53. <https://doi.org/10.1016/j.jbtep.2019.02.006>
- Waters, F., Naik, N., & Rock, D. (2013). Sleep, fatigue, and functional health in psychotic patients. *Schizophrenia Research and Treatment*, *2013*, 1–7. <https://doi.org/10.1155/2013/425826>
- Watkins, E. R., & Roberts, H. (2020). Reflecting on rumination: Consequences, causes, mechanisms and treatment of rumination. *Behaviour Research and Therapy*, *127*, 103573. <https://doi.org/10.1016/j.brat.2020.103573>
- Watkins, E., Scott, J., Wingrove, J., Rimes, K., Bathurst, N., Steiner, H., ... Malliaris, Y. (2007). Rumination-focused cognitive behaviour therapy for residual depression: A case series. *Behaviour Research and Therapy*, *45*, 2144–2154. <https://doi.org/10.1016/j.brat.2006.09.018>
- Young, M. A., Reardon, A., & Azam, O. (2008). Rumination and vegetative symptoms: A test of the dual vulnerability model of seasonal depression. *Cognitive Therapy and Research*, *32*, 567–576. <https://doi.org/10.1007/s10608-008-9184-z>

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