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Registered Report

The influence of emotion regulation strategies and sleep quality on depression and anxiety

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ABSTRACT

Chronic stress is a major risk factor for a number of mental health disorders, including depression and pathological anxiety. Adaptive cognitive emotion regulation (CER) strategies (i.e. positively-focused thought processes) can help to prevent psychiatric disturbance when enduring unpleasant and stressful experiences, but little is known about the inter-individual factors that govern their success. Sleep plays an important role in mental health, and may moderate the effectiveness of adaptive CER strategies by maintaining the executive functions on which they rely. In this study, we carried out a secondary analysis of self-reported mental health and sleep data acquired during a protracted and naturally-occurring stressor – the COVID-19 pandemic – to firstly test the hypothesis that adaptive CER strategy use is associated with positive mental health outcomes and secondly, that the benefits of adaptive CER strategy use for mental health are contingent on high-quality sleep. Using established self-report tools, participants estimated their depression ($N = 551$) and anxiety ($N = 590$)[2] levels, sleep quality and tendency to engage in adaptive and maladaptive CER strategies during the Spring and Autumn of 2020. Using a linear mixed modelling approach, we found that greater use of adaptive CER strategies and higher sleep quality were independently associated with lower self-reported depression and anxiety. However, adaptive CER strategy use was not a significant predictor of self-reported anxiety when accounting for sleep quality in our final model. The positive influence of adaptive CER strategy use on depression was observed at different levels of sleep quality. These findings highlight the

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[2] Due to a minor coding error that resulted in an incorrectly computed predictor measure, we have more missing data than was originally reported in our Stage 1 Registered Report. Our total sample size therefore differs from that reported in our Stage 1 Registered Report for both the pilot study (from n = 118 to n = 117 for the depression sample and from n = 123 to n = 122 for the anxiety sample) and the main study (from n = 562 to n = 551 for the depression sample and from n = 604 to n = 590 for the anxiety sample). These corrections received editorial approval on 30th November 2022.

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importance of adaptive CER strategy use and good sleep quality in promoting resilience to depression and anxiety when experiencing chronic stress.

1. Introduction

Chronic stress is a well-known risk factor for mental illness. However, not all individuals who experience chronic stress go on to experience psychological disturbance. These divergent effects of chronic stress are thought to arise from pre-existing vulnerabilities, which vary between individuals (Marin et al., 2011). Understanding the factors that contribute to the onset of mental health problems when undergoing stressful life events is thus an important step towards reducing the global burden of mental illness.

Psychological responses to stress are influenced by cognitive emotion regulation (CER) strategies, which are thought processes that an individual voluntarily engages in to regulate emotional experiences (Garnefski, Kraaij, & Spinhoven, 2001; Garnefski & Kraaij, 2006). CER strategies can be categorised as adaptive (e.g. positive reappraisal) or maladaptive (e.g. rumination) (Aldao & Nolen-Hoeksema, 2010) and these subtypes are associated with distinct mental health outcomes. Whereas adaptive CER strategies tend to improve psychological wellbeing in the long term (Kirschbaum-Lesch, Holtmann, & Legenbauer, 2021), maladaptive CER strategies provide only short-term respite (Campbell-Sills & Barlow, 2007) and can even amplify affective disturbances (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Garnefski et al., 2001; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Indeed, among clinical populations, more frequent use of self-blame, rumination and catastrophising (maladaptive CER strategies) and less frequent use of positive reappraisal (an adaptive CER strategy) have all been shown to significantly predict higher levels of both depression and anxiety (Aldao & Nolen-Hoeksema, 2010; Domaradzka & Fajkowska, 2018; Garnefski, Legerstee, Kraaij, Van den kommer, & Teerds, 2002; Martin & Dahlen, 2005). Adaptive CER strategy use thus appears to be an important safeguard against the development of mental health problems when undergoing chronic stress.

Adaptive CER strategy use enlists a number of executive functions such as memory updating, flexible task switching and inhibition of prepotent responses (Joormann & Tanovic, 2015; McRae, Jacobs, Ray, John, & Gross, 2012; Ochsner & Gross, 2005). It is therefore likely that factors influencing executive control also impact on our ability to deploy adaptive CER strategies effectively. Consistent with this view, previous work has shown that executive control deficits are associated with less frequent and unsuccessful use of adaptive CER strategies (Joormann, 2010; Joormann & Gotlib, 2010; Malooly, Genet, & Siemer, 2013; Pe, Raes, & Kuppens, 2013; Schmeichel, Volokhov, & Demaree, 2008; Schmeichel & Tang, 2015), potentially undercutting the positive mental health outcomes that they typically afford.

Poor sleep quality is widely associated with executive control deficits (Drummond et al., 1999; Mograss, Guillem, Brazzini-Poisson, & Godbout, 2009; Nilsson et al., 2005; Qi et al., 2010; Skurvydas et al., 2020) and emotion dysregulation (Ben Simon, Rossi, Harvey, & Walker, 2020; Harrington & Cairney, 2021; Harrington, Ashton, Sankarasubramanian, Anderson, & Cairney, 2021; Yoo, Gujar, Hu, Jolesz, & Walker, 2007). Moreover, empirical findings suggest that sleep disturbances are causally related to mental health problems (Baglioni, Spiegelhalder, Lombardo, & Riemann, 2010; Bi & Chen, 2022; Freeman et al., 2017), with a recent meta-analysis showing that improving sleep quality leads to a reduction in self-reported symptoms of depression and anxiety (Scott, Webb, Martyn-St James, Rowse, & Weich, 2021). Unsurprisingly, sleep difficulties also have a negative impact on people's ability to deploy adaptive CER strategies effectively (Mauss, Troy, & LeBourgeois, 2013; Parsons, Schofield, Batziou, Ward, & Young, 2021; Tamm et al., 2019; Zhang, Lau, & Hsiao, 2019). These findings point to a potential mechanistic link between disordered sleep and psychological disturbance, wherein the benefits of adaptive CER strategies (i.e. for downregulating negative emotions and thus preserving mental wellbeing) are contingent on ample and good quality sleep (Mauss et al., 2013; Parsons et al., 2021; Tamm et al., 2019; Zhang et al., 2019). Whether mental health outcomes following a sustained period of stress can be attributed to the relationship between sleep and adaptive CER strategy use, however, has yet to be established.

Stressful experiences often arise unexpectedly and evolve over long periods of time. Yet, research on sleep and adaptive CER strategy use is typically limited to the laboratory, where artificial stressors (e.g. aversive images or videos) are presented very briefly. Participants in laboratory experiments are also trained on how to deploy an array of CER strategies, whereas people in the real world must respond to aversive experiences in the absence of any explicit instruction. Hence, although findings from the laboratory have laid an important foundation for understanding the relationship between sleep, adaptive CER strategy use and mental health outcomes, a crucial next step is to address this question in the context of a naturally-occurring and chronic stressor.

The COVID-19 pandemic has been a prolonged and unique source of stress for people across the entire world. Although many studies have reported significant increases in mental health problems during the pandemic (Morin et al., 2021), others have shown no change or even improvements in psychological wellbeing (Bottary, Fields, Kensinger, & Cunningham, 2021; Cunningham, Fields, Garcia, et al., 2021; Fields, Kensinger, Garcia, Ford, & Cunningham, 2021; Rezaei & Grandner, 2021; Robbins et al., 2021; Tyson & Wild, 2021), highlighting the divergent impacts of sustained emotional hardship. Given the unexpected and protracted nature of COVID-19, it offers a unique context with which to study the influence of adaptive CER strategy use on mental health outcomes when enduring a naturally-occurring and chronic stressor, as well as the moderating role of sleep.

In this study, we capitalised on a longitudinal dataset acquired during the first nine months of the COVID-19 pandemic [dataset] (Cunningham, Fields, & Kensinger, 2021) to investigate the influence of adaptive CER strategy use and sleep quality on changes in self-reported depression and anxiety.

A sample of $N = 1600$ healthy adults provided self-reported scores of depression, anxiety, sleep quality and CER strategy use at multiple time points between March and November of 2020. Our planned analyses of this data allowed us to address two research questions.

1) Is adaptive CER strategy use associated with positive mental health outcomes?
2) Are the mental health benefits of adaptive CER strategy use contingent on good quality sleep?

We tested the following hypotheses using a null hypothesis significance testing framework.

(1) Greater use of adaptive CER strategies will be associated with:
  (a) Decreased self-reported depression.
  (b) Decreased self-reported anxiety.
(2) Higher sleep quality will be associated with
  (a) Decreased self-reported depression.
  (b) Decreased self-reported anxiety.
(3) Use of adaptive CER strategies will be moderated by sleep quality such that:
  (a) The relationship between greater use of adaptive CER strategies and decreased self-reported depression will be stronger at higher levels of sleep quality.
  (b) The relationship between greater use of adaptive CER strategies and decreased self-reported anxiety will be stronger at higher levels of sleep quality.

2. Methods

We report how we determined our sample size, all data exclusions, all inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all manipulations, and all measures in the study.

2.1. *Measures and design*

The accepted Stage 1 manuscript of this Registered Report was registered on the Open Science Framework (OSF) and can be found at: https://osf.io/fxtvg. This study was a secondary analysis of data collected by [dataset] Cunningham, Fields, & Kensinger, 2021; https://osf.io/gpxwa/. The cited data descriptor contains additional information on the data collection process (beyond that described below), should it be required. See Table 1 for our study design table and Fig. 1 for an overview of the data collection periods for each of the measures included in our analysis.

All participants provided consent via an online form and were invited to complete the following.

2.1.1. *Demographic survey*

The demographic survey included the following items: age, biological sex, gender identity, ethnicity, race, current residence and previous diagnoses of mental health disorders.

2.1.2. *Cognitive emotion regulation questionnaire*

The Cognitive Emotion Regulation Questionnaire-short version (CERQ-short; Garnefski & Kraaij, 2006) is an eighteen-item, self-report questionnaire designed to identify the emotion regulation strategies that individuals use after experiencing a negative event or situation. Participants are asked to rate how often they use nine conceptually different CER strategies (two questionnaire items per strategy) on a scale ranging from 1 (*almost never*) to 5 (*almost always*). Individual scores for each CER strategy are obtained by summing the two questionnaire items associated with each strategy to form an overall score (ranging from 2 to 10). The higher the overall score, the more a CER strategy is used. CER strategies can be dichotomised as adaptive and maladaptive (Garnefski et al., 2001). Adaptive CER strategies include *refocus on planning* (i.e. thinking about the next steps and how to handle the negative event), *positive refocusing* (i.e. turning thoughts towards joyful and pleasant matters), *positive reappraisal* (i.e. attaching a positive meaning to an event) and *putting into perspective* (i.e. downregulating the seriousness of the event and comparing it to other events). Although *acceptance* (i.e. coming to terms with the situation that has occurred) has been previously classified as an adaptive CER strategy, there are concerns that it may only be adaptive under certain circumstances (Martin & Dahlen, 2005). Consequently, it is not considered as either an adaptive or maladaptive CER strategy in the current study. Maladaptive CER strategies include *self-blame* (i.e. blaming oneself for what they have experienced), *other-blame* (i.e. blaming others for what they have experienced), *rumination* (i.e. dwelling on the negative feelings or thoughts associated with an event) and *catastrophising* (i.e. overemphasising the negative parts of an experience). Overall, the CERQ-short has demonstrated good validity and reliability in the general population (Araujo et al., 2020; Garnefski & Kraaij, 2006). In the current dataset, the CERQ-short was administered once in Spring 2020, between 19th May and 26th August.

To assess adaptive CER strategy use, we created a composite score by summing the scores for all adaptive items on the CERQ-short (*positive refocusing, refocus on planning, positive reappraisal, putting into perspective*). Scores ranged from 8 to 40 (two questionnaire items per adaptive CER strategy), with higher scores indicating more frequent use of adaptive CER strategies. Higher scores on this composite measure of adaptive CER strategy use have been associated with positive mental health outcomes in previous work (e.g. lower prevalence of depression and anxiety; Domaradzka & Fajkowska, 2018; Garnefski et al., 2001).

We also assessed maladaptive CER strategy use (for inclusion in exploratory analyses). To do so, we created a composite score by summing the scores for all maladaptive items on the CERQ-short (*self-blame, other-blame, rumination, catastrophising*). Scores ranged from 8 to 40 (two questionnaire items per maladaptive CER strategy), with higher scores

Table 1 – Hypotheses, sampling plan, analysis plan, and interpretations for each of our primary research questions.

Aim	Hypothesis	Sampling plan	Analysis plan	Interpretation given different outcomes
1. Is adaptive CER strategy use associated with positive mental health outcomes?	**1a.** Greater use of adaptive CER strategies will be associated with decreased self-reported depression.	Power analyses have been computed to calculate the minimum effect sizes which can be detected at 90% power and .02 alpha level for each fixed effect and interaction effect in Model 2, addressing hypotheses 1a and 1b (Table 2).	We will perform a linear mixed effects analysis of the relationship between adaptive CER strategy use and depression over time, as indexed by the change from baseline to follow-up. As fixed effects, we will enter: 1) time as a categorical predictor and 2) adaptive CER strategy use as a continuous predictor (grand-mean centred). We will also include a random intercept for participants. Age, biological sex and mental health diagnosis will be included as covariates along with the interactions between covariates and the predictors. Depression ~1 + time*age + time*biological sex + time*mental health diagnosis + adaptive CER strategy use*age + adaptive CER strategy use*biological sex + adaptive CER strategy use*mental health diagnosis + time*adaptive CER strategy use + (1 | participant).	**Significant**: If there is a main effect of time it can be concluded that depression changes from baseline to follow-up. If there is a main effect of adaptive CER strategy use it can be concluded that adaptive CER strategy use influences depression. If there is an interaction between time and adaptive CER strategy use it can be concluded that adaptive CER strategy use leads to a change in depression from baseline to follow-up. If there is a main effect of age it can be concluded that age influences depression. If there is a main effect of sex it can be concluded that sex (female/male) influences depression. If there is a main effect of mental health diagnosis it can be concluded that mental health diagnosis (yes/no) influences depression.
	1b. Greater use of adaptive CER strategies will be associated with decreased self-reported anxiety.		We will perform a linear mixed effects analysis of the relationship between adaptive CER strategy use and anxiety over time, as indexed by the change from baseline to follow-up. As fixed effects, we will enter: 1) time as a categorical predictor and 2) adaptive CER strategy use as a continuous predictor (grand-mean centred). We will also include a random intercept for participants. Age, biological sex and mental health diagnosis will be included as covariates along with the interactions between covariates and the predictors. Anxiety ~1 + time*age + time*biological sex + time*mental health diagnosis + adaptive CER strategy use*age + adaptive CER strategy use*biological sex + adaptive CER strategy use*mental health diagnosis + time*adaptive CER strategy use + (1 | participant).	**Significant**: If there is a main effect of time it can be concluded that anxiety changes from baseline to follow-up. If there is a main effect of adaptive CER strategy use it can be concluded that adaptive CER strategy use influences anxiety. If there is an interaction between time and adaptive CER strategy use it can be concluded that adaptive CER strategy use leads to a change in anxiety from baseline to follow-up. If there is a main effect of age it can be concluded that age influences anxiety. If there is a main effect of sex it can be concluded that sex (female/male) influences anxiety. If there is a main effect of mental health diagnosis it can be concluded that mental health diagnosis (yes/no) influences anxiety.

(continued on next page)

Table 1 – (*continued*)

Aim	Hypothesis	Sampling plan	Analysis plan	Interpretation given different outcomes
2. Are the mental health benefits of adaptive CER strategy use contingent on good quality sleep?	**2a.** Higher sleep quality will be associated with decreased self-reported depression. **3a.** Use of adaptive CER strategies will be moderated by sleep quality such that the relationship between greater use of adaptive CER strategies and decreased self-reported depression will be stronger at higher levels of sleep quality.	Power analyses have been computed to calculate the minimum effect sizes which can be detected at 90% power and .02 alpha level for each fixed effect and interaction effect in Model 3i and 3ii, addressing hypothesis 2a and 2b, and 3a and 3b, respectively (Table 2).	We will perform a linear mixed effects analysis of the moderating role of sleep quality on the relationship between adaptive CER strategy use and depression over time, as indexed by the change from baseline to follow-up. As fixed effects, we will enter: 1) time as a categorical predictor and 2) adaptive CER strategy use and 3) sleep quality as continuous predictors (grand-mean centred). We will also include a random intercept for participants. Age, biological sex and mental health diagnosis will be included as covariates along with the interactions between covariates and the predictors. Depression ~1 + time*adaptive CER strategy use*age + time*adaptive CER strategy use*biological sex + time*adaptive CER strategy use*mental health diagnosis + time*sleep quality*age + time*sleep quality*biological sex + time*sleep quality*mental health diagnosis + adaptive CER strategy use*sleep quality*age + adaptive CER strategy use*sleep quality*biological sex + adaptive CER strategy use*sleep quality*mental health diagnosis + time*adaptive CER strategy use*sleep quality + (1 | participant).	**Significant:** If there is a main effect of sleep quality it can be concluded that sleep quality influences depression. If there is an interaction between time and sleep quality it can be concluded that sleep quality leads to a change in depression from baseline to follow-up. If there is an interaction between adaptive CER strategy use and sleep quality it can be concluded that sleep quality influences the relationship between adaptive CER strategy use and depression. If there is an interaction between adaptive CER strategy use, sleep quality and time it can be concluded that sleep quality influences the relationship between adaptive CER strategy use and the change in depression from baseline to follow-up.
	2b. Higher sleep quality will be associated with decreased self-reported anxiety. **3b.** Use of adaptive CER strategies will be moderated by sleep quality such that the relationship between greater use of adaptive CER strategies and decreased self-reported anxiety will be stronger at higher levels of sleep quality.		We will perform a linear mixed effects analysis of the moderating role of sleep quality on the relationship between adaptive CER strategy use and anxiety over time, as indexed by the change from baseline to follow-up. As fixed effects, we will enter: 1) time as a categorical predictor and 2) adaptive CER strategy use and 3) sleep quality as continuous predictors (grand-mean centred). We will also include a random intercept for participants. Age, biological sex and mental health diagnosis will be included as covariates along with the interactions between covariates and the predictors. Anxiety ~1 + time*adaptive CER strategy use*age + time*adaptive CER strategy use*biological sex + time*adaptive CER strategy use*mental health diagnosis + time*sleep quality*age + time*sleep quality*biological sex + time*sleep quality*mental health diagnosis + adaptive CER strategy use*sleep quality*age + adaptive CER strategy use*sleep quality*biological sex + adaptive CER strategy use*sleep quality*mental health diagnosis + time*adaptive CER strategy use*sleep quality + (1 | participant).	**Significant:** If there is a main effect of sleep quality it can be concluded that sleep quality influences anxiety. If there is an interaction between time and sleep quality it can be concluded that sleep quality leads to a change in anxiety from baseline to follow-up. If there is an interaction between adaptive CER strategy use and sleep quality it can be concluded that sleep quality influences the relationship between adaptive CER strategy use and anxiety. If there is an interaction between adaptive CER strategy use, sleep quality and time it can be concluded that sleep quality influences the relationship between adaptive CER strategy use and the change in anxiety from baseline to follow up.

Table 2 – Minimum detectable effect sizes and 95% confidence interval based on a simulated dataset with 90% power and .02 alpha level.

Effect Size (ES)	*Depression*		*Anxiety*	
	B [CIs]	*β [CIs]*	*B [CIs]*	*β [CIs]*
Model 2				
Time	.66 [.65 - .68]	.11 [.11 - .11]	.83 [.78 - .87]	.15 [.15 - .16]
Adaptive CER Strategy Use	.17 [.16 - .18]	.19 [.18 - .20]	.16 [.15 - .17]	.19 [.18 - .20]
Time X Adaptive CER Strategy Use	.07 [.07 - .08]	.09 [.09 - .09]	.11 [.10 - .11]	.11 [.11 - .12]
Model 3				
Time	.72 [.70 - .74]	.12 [.11 - .13]	1.02 [1.01 – 1.04]	.19 [.18 - .19]
Adaptive CER Strategy Use	.17 [.18 - .18]	.17 [.16 - .17]	.16 [.15 - .17]	.16 [.15 - .16]
Sleep Quality	.31 [.30 - .32]	.17 [.16 - .17]	.36 [.34 - .37]	.20 [.19 - .21]
Time X Adaptive CER Strategy Use	.14 [.14 - .15]	.12 [.11 - .12]	.18 [.17 - .19]	.16 [.16 - .17]
Time X Sleep Quality	.31 [.30 – .33]	.14 [.14 - .14]	.46 [.45 - .48]	.22 [.21 - .22]
Adaptive CER Strategy Use X Sleep Quality	.08 [.07 - .08]	.19 [.18 - .19]	.08 [.08 – .08]	.19 [.18 - .20]
Time X Adaptive CER Strategy Use X Sleep Quality	.03 [.03 - .04]	.09 [.09 - .10]	.05 [.05 - .05]	.12 [.12 – .13]

B = Non-standardised ES, β = Standardised ES.[8]

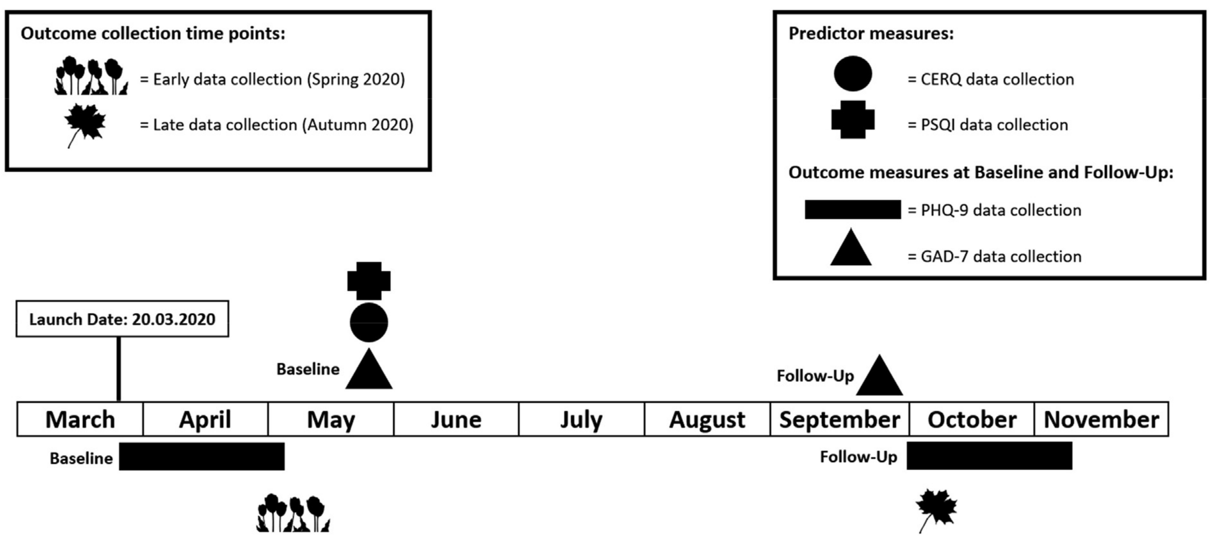

Fig. 1 – Schematic of the Study Timeline. The PSQI and CERQ were administered once between May and August 2020. PHQ-9 responses were collected between March and May 2020 (Baseline) and again between October and November 2020 (Follow-Up). GAD-7 responses were collected between May and June 2020 (Baseline) and again between September and November 2020 (Follow-Up). For the purpose of our analyses, March to June 2020 is referred to as the early data collection period (Spring 2020) and September to November 2020 is referred to as the late data collection period (Autumn 2020).

indicating more frequent use of maladaptive CER strategies. Higher scores on this composite measure of maladaptive CER strategy use have been associated with negative mental health outcomes in previous work (e.g. higher prevalence of depression and anxiety; Domaradzka & Fajkowska, 2018; Garnefski et al., 2001).

2.1.3. *Pittsburgh sleep quality index*

The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) is a self-report questionnaire designed to assess sleep quality over the preceding month. The questionnaire consists of nineteen items, which are grouped to form seven sub-scores: (1) subjective sleep quality, (2) sleep latency, (3) sleep duration, (4) sleep efficiency, (5) sleep disturbance, (6) use of sleep medication and (7) daytime dysfunction. Each sub-score ranges from 0 to 3, with 3 reflecting the poorest sleep quality. Sub-scores are then summed to produce a global score, which ranges from 0 to 21. Higher global scores indicate poorer sleep quality. The PSQI has demonstrated strong reliability and validity in both clinical and non-clinical samples (Buysse et al., 1989; Mollayeva et al., 2016). In the current dataset, the PSQI was administered once in Spring 2020, between 19th May and 26th August.

2.1.4. *Patient health questionnaire*

The Patient Health Questionnaire (PHQ-9; Kroenke, Spitzer, & Williams, 2001) is a nine-item self-report questionnaire designed to measure depression severity. Participants report

[8] For reasons noted in footnote 1, our pilot sample size has changed and, as such, our minimum detectable effect sizes and 95% confidence intervals have changed.

how often they have been bothered by nine core symptoms of depression over the preceding fortnight. Each item is rated on a Likert scale from 0 (*not at all*) to 3 (*nearly every day*). Usually, all nine items are summed to create a total score ranging from 0 to 27. However, the suicidality item was omitted during data collection, and so we summed the remaining eight items to create a modified score ranging from 0 to 24. A higher modified score indicates higher depression severity. Prior evidence indicates that the PHQ-9 has excellent internal reliability in both clinical (Cronbach's $\alpha = .89$) and non-clinical (Cronbach's $\alpha = .87$) samples (Kocalevent, Hinz, & Brähler, 2013; Kroenke et al., 2001).

The PHQ-9 was assessed across two time periods: Spring and Autumn 2020 (both five weeks in duration). For the Spring 2020 data collection period, depression data was collected between 21st March and 1st May, and for the Autumn 2020 data collection period, depression data was collected between 1st October and 14th November. Participants were invited to complete the PHQ-9 on two days of each assessment week. The PHQ-9 was administered pseudorandomly such that the randomly selected days in the first week were then eliminated from choice in the following week until the PHQ-9 had been assessed on each day of the week before starting over. This ensured that the days of the week were sampled evenly. There were some weeks where the PHQ-9 was administered more than twice a week. Firstly, in the first week of the Spring period, when the study launched, participants were invited to complete the PHQ-9 on all seven days of the assessment week (21/03/2020-27/03/2020) before this was dropped down to two times a week to reduce participant burden. Secondly, the PHQ-9 was administered four times a week instead of two times a week during the fortnight around the US election (31/10/2020-14/11/2020). The PHQ-9 was therefore administered more frequently than the PSQI, CERQ, and the GAD-7, with the PSQI and CERQ being administered only once in Spring, and the GAD-7 being administered once in Spring and once again in Autumn (see below). All PHQ-9 scores (modified total score of 0–24) collected in the Spring period were averaged to create a mean baseline depression index. Similarly, all PHQ-9 scores collected in the Autumn period were averaged to create a mean follow-up depression index.

2.1.5. *Generalised anxiety disorder questionnaire*

The Generalised Anxiety Disorder Questionnaire (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006) is a seven-item self-report questionnaire designed to measure anxiety severity. Participants report how often they have been bothered by seven core symptoms of generalised anxiety disorder over the preceding fortnight. Items are scored from 0 (*not at all*) to 3 (*nearly every day*) and a total score is obtained by summing across all individual items. The total score ranges from 0 to 21, with higher scores indicating a higher severity of generalised anxiety. The GAD-7 has excellent internal reliability in both clinical (Cronbach's $\alpha = .92$) and non-clinical (Cronbach's $\alpha = .89$) samples (Löwe et al., 2008; Spitzer et al., 2006).

The GAD-7 was assessed in Spring and Autumn 2020 (once at each time point). For the Spring 2020 data collection period, anxiety data was collected between 19th May and 30th June, and for the Autumn 2020 data collection period, anxiety data was collected between 28th September and 9th November. The Spring data collection period was therefore slightly later for the anxiety data than the depression data, whereas the Autumn data collection period was highly overlapping for the anxiety and depression data. The GAD-7 score collected in the Spring formed a baseline anxiety index, whereas the GAD-7 score collected in the Autumn formed a follow-up anxiety index.

2.2. *Participants*

$N = 1600$ participants (77.0% females, age $M = 35.05$ years, $SD = 15.03$ years) completed the initial demographic survey. Our final samples (for depression and anxiety) were obtained after applying the exclusion procedures described below (see *Exclusion Criteria*). Because the PHQ-9 and GAD-7 were collected at different times in the Spring and Autumn of 2020, the final sample sizes differ for each measure (depression $N = 551$: 457 female, age $M = 39.12$, $SD = 17.07$ years; anxiety $N = 590$: 489 female, age $M = 38.49$, $SD = 16.89$). Of the depression sample, 98.7% of participants were also included in the anxiety sample. Likewise, of the anxiety sample, 92.2% of participants were also included in the depression sample[3]. See Supplementary Methods for a detailed overview of demographics in our depression and anxiety samples.

Participants were entered into raffles to receive gift cards. Ethical approval for the original study was obtained by the Institutional Review Board at Boston College, USA, and the current study has been approved by the Research Ethics Committee of the Department of Psychology at the University of York, UK.

2.3. *Exclusion criteria*

Because COVID-19 restrictions (e.g. nationwide lockdowns) varied according to country, we excluded participants who were not residing in the United States (US) at the time of data collection. Non-US participants were used instead in our pilot analyses (see *Statistical Analysis*). Participants with missing item data on the CERQ or PSQI (predictor measures) were excluded from all analyses. Participants with missing item data on the PHQ-9 and/or GAD-7 (outcome measures) during both assessment periods (Spring and Autumn) were excluded from the analysis of depression and/or anxiety, respectively. Participants who fully completed the PHQ-9 and/or GAD-7 at one of the two assessment periods (Spring or Autumn) were, however, included in the respective analysis of depression and/or anxiety. For the depression sample, $N = 226$ completed time point one only, $N = 44$ completed time point two only, and $N = 281$ completed both time points. For the anxiety sample, $N = 239$ completed time point one only, $N = 16$ completed time point two only and $N = 335$ completed both time points.[4] A full breakdown on how we reached our final sample sizes, for both the depression and anxiety outcomes, can be found in the Supplementary Methods.

[3] Due to a minor coding error, our total sample size has changed. See footnote 1 for further details.

[4] For reasons noted in footnote 1, our total sample size has changed.

2.4. Statistical Analysis

Our predictor measures were the CERQ (adaptive CER strategies composite score) and PSQI (total score). Our outcome measures were the PHQ-9 (mean modified total score) and the GAD-7 (total score) at baseline (Spring) and follow-up (Autumn).

To formulate our analysis pipeline and conduct a power analysis, we created a pilot dataset using the non-US participants (excluded from our main analysis). Sample sizes for our pilot analyses of depression and anxiety were $N = 117$ and $N = 122$, respectively.[5]

2.4.1. Self-certification of data blindness

All authors remained blind to the data from the US participants that was used in our planned analyses prior to in principal acceptance of the manuscript.

2.4.2. Planned analyses

All hypotheses were tested using linear mixed effects models with a random intercept for participants. We carried out two models per hypothesis (corresponding to the two outcome measures of depression and anxiety) with an alpha threshold of .05 (corrected for the false discovery rate). To quantify the evidence in support of the experimental (H_1) or null hypotheses (H_0), we calculated Bayes Factors for each effect of interest (Wetzels & Wagenmakers, 2012) using Jeffrey's (1961) conventional cut-offs to determine the strength of the evidence.

We included age and biological sex as covariates in all models because they have been found to influence both emotion regulation (Costa Martins, Freire, & Ferreira-Santos, 2016; Ford, DiBiase, & Kensinger, 2018; Ford, DiBiase, Ryu, et al., 2018) and sleep quality in previous work (Buysse et al., 1991; Madrid-Valero, Martínez-Selva, Couto, Sánchez-Romera, & Ordoñana, 2017; Middelkoop, Smilde-van den Doel, Neven, Kamphuisen, & Springer, 1996). Specifically, older age has been associated with an increased focus on the positive aspects of emotional events (Ford, DiBiase, & Kensinger, 2018; Ford, DiBiase, Ryu, et al., 2018), lower depression symptomatology over the initial course of the COVID-19 pandemic (Cunningham, Fields, Garcia, et al., 2021; Fields et al., 2021) and poorer sleep quality (Buysse et al., 1991; Madrid-Valero et al., 2017), suggesting that the link between sleep quality and adaptive CER strategy use might be tempered in older relative to younger adults. Along similar lines, females report less frequent use of adaptive CER strategies (Costa Martins et al., 2016; Kelly, Tyrka, Price, & Carpenter, 2008) and poorer sleep quality than males (Buysse et al., 1991; Middelkoop et al., 1996), meaning that the link between sleep quality and adaptive CER use may be stronger in females than males. We also included the interactions between these covariates and our variables of interest [Time, PSQI, CERQ] in each of our models. See Table 1 for an overview of each model.

Standard assumptions of linear mixed models (i.e. linearity, homogeneity of variance, multicollinearity, normality of residuals, and influential data points) were checked throughout the modelling process. We used a decision tree to check model assumptions and carry out appropriate transformations of the data in the event that any assumptions were violated (see Supplementary Methods). Because linear models are relatively robust to violations of distributional assumptions (such as normality of residuals; Schielzeth et al., 2020), any model issues that were not satisfactorily resolved are reported and the results interpreted with necessary caution. All continuous predictors and covariates in the linear mixed models were grand mean-centred to enhance the interpretability of model intercepts (Enders & Tofighi, 2007). We used simple slopes analysis with Johnson-Neyman intervals to probe any significant two-way and three-way interactions in Model 2 and Model 3, respectively (Carden, Holtzman, & Strube, 2017; Lin, 2020). In case non-convergence issues arose in our final dataset, we produced a workflow outlining the steps we would take to address such matters. This is illustrated in the Supplementary Methods.

All analyses were conducted using R (v.4.0.2) with the R packages *lme4* (Bates, Mächler, Bolker, & Walker, 2015), *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2017) and *afex* (Singmann et al., 2021). These packages were used to model regressions and calculate P-values using Satterthwaite approximations. Plots were created with the R package *ggplot2* (Wickham, 2016). The code for our linear mixed effects models has been adapted from Rodriquez-Seijas et al. (2020; https://osf.io/ur27h/).

2.4.2.1. Model 1, baseline model investigating the effect of time on self-reported depression and anxiety. Model 1 was used as a baseline model to investigate the effect of time on depression (PHQ-9 mean modified total score) and anxiety (GAD-7 total score), as indexed by the change from baseline to follow-up. From this model, we were able to determine whether depression and/or anxiety change from Spring to Autumn 2020 in the absence of any predictor variables. Accordingly, the only fixed effect was time, which was added as a categorical predictor alongside the covariates. Time-bin was simple coded (early = −.5, late = .5). Previous studies using the same dataset as ours (and similar models) have shown a significant effect of time on depression during the early to later months of the pandemic (i.e. a reduction in PHQ-9 scores; Fields et al., 2021; Rodriguez-Seijas et al., 2020). The effect of time on anxiety has yet to be investigated in this dataset, but findings from other COVID-19 datasets have indicated that anxiety has followed a similar trajectory to depression (Carr et al., 2022; Fancourt, Steptoe, & Bu, 2020; Kujawa, Green, Compas, Dickey, & Pegg, 2020; O'Connor et al., 2020; Velden et al., 2021).

2.4.2.2. Model 2, testing hypotheses 1a and 1b: greater use of adaptive CER strategies will be associated with decreased self-reported depression and anxiety over time. Model 2 addressed the effect of adaptive CER strategy use on depression and anxiety. The adaptive CER strategies (composite) score was added as a continuous fixed effect, alongside the interaction between the adaptive CER strategies score and time. Support for our hypotheses will be indicated by a significant interaction between the adaptive CER strategies score and time on self-reported depression and/or anxiety ($P < .05$), such that

[5] Our pilot sample size has also changed.

greater use of adaptive CER strategies will be associated with a decrease in depression and/or anxiety from baseline.

2.4.2.3. Model 3 (i), testing hypotheses 2a and 2b: higher sleep quality will be associated with decreased self-reported depression and anxiety over time. Model 3 addressed the effect of sleep quality on depression and anxiety. The sleep quality (PSQI) score was added to the baseline model as a continuous fixed effect, alongside the interaction between the sleep quality score and time. Support for our hypotheses will be indicated by a significant interaction between time and the sleep quality score on self-reported depression and/or anxiety ($P < .05$), such that higher sleep quality will be associated with a decrease in depression and/or anxiety from baseline.

2.4.2.4. Model 3 (ii), testing hypotheses 3a and 3b: the relationship between greater use of adaptive CER strategies and decreased self-reported depression and anxiety will be stronger at higher levels of sleep quality. The three-way interaction between sleep quality score, adaptive CER strategies score and time was added to Model 3 to investigate whether sleep quality moderates the relationship between adaptive CER strategy use and either depression or anxiety. Support for our hypotheses will be indicated by a significant three-way interaction between time, adaptive CER strategies score and sleep quality score on depression and/or anxiety ($P < .05$), such that the relationships described for Model 2 will be stronger at higher (above average) levels of sleep quality.

2.4.3. *Missing data*

Maximum likelihood was used to handle missing outcome data (e.g. when PHQ-9 and/or GAD-7 data is only available for the early or late time point). Consistent with ordinary least squares regression, maximum likelihood uses all of the available outcome data – complete and incomplete – to identify parameter values that maximise the fit of the model with the observed data (Baraldi & Enders, 2010; Brown, 2021). Note that the PHQ-9 was administered numerous times within each assessment period (with a mean score calculated across all scores within that period), meaning that participants must have fully completed the PHQ-9 at least once during the Spring or Autumn to be included in the analysis of depression.

2.5. *Power analysis*

The sample size for this study was already determined by the secondary data available. However, it is important to determine whether the data available can provide a sufficiently powered test of our key hypotheses. We used a data simulation approach to calculate the minimum effect sizes that we were able to detect with 90% power, an alpha threshold of .02 and the sample available for each analysis (depression $N = 551$; anxiety $N = 590$).[6] If these minimum effect sizes are comparable to or smaller than those expected in the context of the current literature, we can be reassured that the data provide a suitable means of addressing of our research questions. Please note that the 90% power and alpha threshold of .02 were selected in accordance with Cortex's Registered Report guidelines for power analyses. We chose an alpha threshold of .05 for our main analyses to protect against overly conservative P-values when controlling for the false discovery rate.

Simulated datasets were generated from the model parameters extracted from the pilot analyses (depression $N = 117$; anxiety $N = 122$; see Supplementary Methods).[7] For each hypothesis, we varied the size of the associated model coefficient that generated the simulated data, ranging from 0 (i.e. a null effect) to the maximum effect size indicated by the 95% confidence intervals. By generating and analysing 1000 datasets at varying effect sizes in this range, we calculated the minimum effect size at which 90% of the tests were statistically significant at $P < .02$ (see Table 2).

Although we report non-standardised coefficients in our main analyses—allowing direct interpretation of the model coefficients in relation to unit changes in the measures—we computed standardised coefficients to examine the minimum detectable effect sizes within the context of the current literature. There is a limited literature on which to base reasonable effect size estimates for the moderating role of sleep on adaptive CER strategy use and mental health outcomes. A recent cross-sectional study examined the influence of adaptive CER strategy use and sleep quality on depression, using a structural equation modelling approach (Nicholson, Lewis, Thomas, & Lipinska, 2021) and estimated a standardised path coefficient of .12. Our simulations for the interaction between adaptive CER strategy use and sleep quality on depression (Model 3) estimated that we have sufficient power to test an effect of similar magnitude ($\beta = .19$).[9]

To determine the sensitivity of our models to false positives, we ran an additional simulation analysis with all beta coefficients for the effects of interest set to 0. Because Model 3 includes all of our effects of interest, we deemed it reasonable to carry out this simulation on Model 3 alone (separately for depression and anxiety). These simulations confirmed that the proportion of false positives produced by the models was in line with the alpha level of .02 (see Supplementary Methods).

3. Results

3.1. *Pre-registered analyses*

The data files and scripts for our pre-registered and exploratory analyses can be found at: https://osf.io/x952b/. Both the depression and anxiety outcome measures violated the assumptions of linearity and homoskedascity. An initial log(10) transformation did not resolve these violations so we applied a Box–Cox transformation and report the results using these transformed outcome variables. To control for multiple comparisons, we report P-values adjusted for the false discovery rate (FDR; Benjamini & Hochberg, 1995). Cohen's d for each

[6] For reasons noted in footnote 1, our total sample size has changed.

[7] Our pilot sample size has also changed.

[9] For reasons outlined in footnote 1, the minimum detectable effect size for the interaction between adaptive CER strategy use and sleep quality on depression has changed.

Table 3 – (a) Descriptive statistics for PHQ-9, GAD-7, CERQ Adaptive Composite Score and PSQI total score. Early and late time point PHQ-9 and GAD-7 total scores are reported for each of the depression and anxiety datasets, respectively. CERQ Adaptive Composite score and PSQI total score are reported for both the depression and anxiety datasets. (b) Distribution of depression and anxiety severity levels, based on cut-off scores for the PHQ-9 and GAD-7 during Spring and Autumn 2020. None-minimal indicates no or minimal depression and/or anxiety symptomatology. Mild to severe indicates respective levels of depression and/or anxiety symptomatology.

(a)	Depression Dataset		Anxiety Dataset	
	PHQ-9[a]^		GAD-7[a]	
Time Bin	Early	Late	Early	Late
Mean [SD]	6.24 [4.30]	5.42 [4.25]	6.14 [4.84]	6.11 [4.83]
Median [IQR]	5.50 [5.52]	4.67 [5.67]	5.00 [7.00]	5.00 [5.50]
Range	0–23	0–20.30	0–21	0–21
	CERQ (Adaptive)	**PSQI**	**CERQ (Adaptive)**	**PSQI**
Mean [SD]	22.66 [5.89]	6.17 [3.24]	22.63 [5.92]	6.14 [3.25]
Median [IQR]	22.00 [8.25]	5.50 [4.00]	22.00 [9.00]	6.00 [4.00]
Range	9–40	0–16	9–40	0–16
(b)	**PHQ-9[a]**		**GAD-7[a]**	
Time Bin	**Early**	**Late**	**Early**	**Late**
None-minimal	182	143	256	156
Mild	213	128	191	126
Moderate	84	38	91	37
Moderately Severe	23	15	NA	NA
Severe	5	1	36	32

[a] Descriptive statistics and cut-off scores were calculated on the non-transformed outcome variables to facilitate interpretation. ^PHQ-9 scores were modified due to the omission of the suicidality item so total score ranges from 0 to 24 instead of the typical 0–27.

effect of interest was calculated using the *EMAtools* R package (Kleiman, 2021). Bayes Factors were computed using the *BayesFactor* R package (Morey & Rouder, 2022) and can be interpreted in line with Jeffrey's criterion (Jeffreys, 1961).

Table 3 shows the descriptive statistics for the depression and anxiety datasets. Table 4 shows correlations among all examined variables for the (a) self-reported depression models and (b) self-reported anxiety models. We found a significant negative association between adaptive CER strategy use and both depression ($r_s = -.24$, $P < .001$) and anxiety ($r_s = -.19$, $P < .001$), such that greater use of adaptive CER strategies was associated with lower depression and anxiety scores. There was also a significant positive association between sleep quality and both depression ($r_s = .51$, $P < .001$) and anxiety ($r_s = .44$, $P < .001$); with lower scores on the PSQI reflecting higher sleep quality. Thus, higher sleep quality was associated with lower depression and anxiety scores. Furthermore, there was a significant negative

Table 4 – Spearman's correlations (r_s) between all examined variables for (a) self-reported depression and (b) self-reported anxiety. Statistically significant correlations are shown in bold. Multiple comparisons correction was applied using Holm's method (Hochberg, 1988).

(a)	Time	Age	Biological Sex	Mental Health Diagnosis	Adaptive CER Strategy Use	Sleep Quality	PHQ-9[a]
Time	–						
Age	.04	–					
Biological Sex	−.01	.07	–				
Mental Health Diagnosis	.02	**.13**	.09	–			
Adaptive CER Strategy Use	<.01	.11	.02	.10	–		
Sleep Quality	.01	.05	−.03	**−.19**	**−.22**	–	
PHQ-9[a]	−.10	**−.11**	−.03	**−.25**	**−.24**	**.51**	–
(b)	Time	Age	Biological Sex	Mental Health Diagnosis	Adaptive CER Strategy Use	Sleep Quality	GAD-7[a]
Time	–						
Age	.05	–					
Biological Sex	−.02	.09	–				
Mental Health Diagnosis	.01	.10	.10	–			
Adaptive CER Strategy Use	.02	.10	.02	.10	–		
Sleep Quality	.01	.06	−.06	**−.19**	**−.21**	–	
GAD-7[a]	<.01	**−.13**	−.10	**−.24**	**−.19**	**.44**	–

[a] Total scores after Box–Cox transformation.

Table 5 – Model 1 coefficients with 95% confidence intervals. Model 1 included participant variables (age, biological sex and mental health diagnosis) and time (period during which self-reported depression or anxiety measures were collected). Separate models were run for depression (PHQ-9) and anxiety (GAD-7). Statistically significant coefficients are shown in bold.

	PHQ-9[a]			GAD-7[a]		
	B [CIs]	*β [CIs]*	*p*	*B [CIs]*	*β [CIs]*	*p*
Intercept	**2.70 [2.59, 2.81]**	−.02 [-.10, .05]	–	**2.62 [2.51, 2.73]**	.01 [-.07, .08]	-
Age	**−.01 [-.01, -.00]**	**−.10 [-.18, -.02]**	**.045**	**−.01 [-.02, -.01]**	**−.15 [-.22, -.07]**	**.001**
Biological Sex	−.03 [-.33, .27]	−.01 [-.09, .07]	.940	−.24 [-.54, .06]	−.06 [-.13, .01]	.392
Mental Health Diagnosis	**−.76 [-1.03, -.49]**	**−.22 [-.30, -.14]**	**<.001**	**−.74 [-1.01, -.46]**	**−.20 [-.28, -.13]**	**<.001**
Time	**−.25 [-.37, -.14]**	**−.18 [-.26, -.09]**	**<.001**	.04 [-.08, .16]	.03 [-.05, .11]	.777

B = Non-standardised coefficients, β = Standardised coefficients.
[a] PHQ-9 and GAD-7 outcome variables were transformed using the Box–Cox transformation.

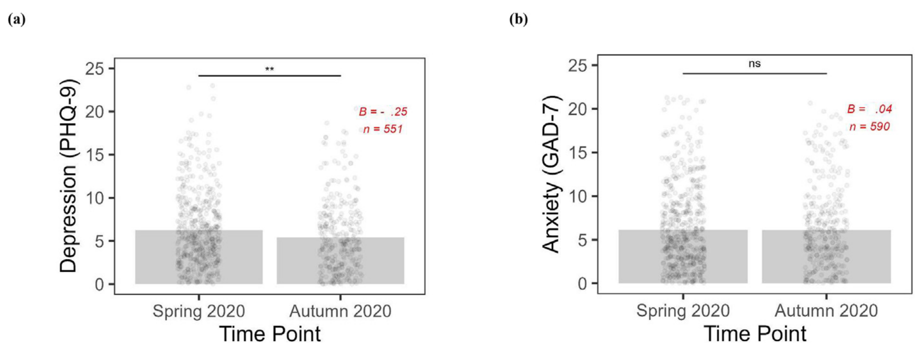

Fig. 2 – Changes in (a) self-reported depression and (b) self-reported anxiety over time (Model 1). Depression significantly decreased from Spring to Autumn 2020. However, there was no significant change in anxiety from Spring to Autumn 2020. Non-transformed outcomes are shown for visualisation purposes. **P < .01, ns = non-significant (P > .05).

association between sleep quality and adaptive CER strategy use in both the depression ($r_s = -.22$, $P < .001$) and anxiety datasets ($r_s = -.21$, $P < .001$), such that higher sleep quality was associated with greater use of adaptive CER strategies.

Model 1, Effect of Time: Coefficients and inferential statistics for Model 1 are shown for depression and anxiety in Table 5. These outcomes are also illustrated in Fig. 2. There was a main effect of time on depression ($B = -.25$ [−.37, −.14], $P < .001$, $d = -.46$), such that depression decreased from Spring to Autumn 2020. However, there was no main effect of time on anxiety ($B = .04$ [−.08, .16], $P = .777$, $d = .07$). Age significantly predicted both depression ($B = -.01$ [−.01, −.00], $P = .045$, $d = -.22$) and anxiety ($B = -.01$ [−.02, −.01], $P = .001$, $d = -.31$), such that increased age was associated with lower depression and anxiety, consistent with prior work (Cunningham, Fields, Garcia, et al., 2021). There was no main effect of biological sex (female/male) on depression ($B = -.03$ [−.33, .27], $P = .940$, $d = -.02$) or anxiety ($B = -.24$ [−.54, .06], $P = .392$, $d = -.13$). For both datasets, there was a main effect of current mental health diagnosis (depression: $B = -.76$ [−1.03, −.49], $P < .001$, $d = -.45$; anxiety: $B = -.74$ [−1.01, −.46], $P < .001$, $d = -.42$): individuals with a currently diagnosed mental health condition had significantly higher depression and anxiety than individuals without diagnosed mental illness.

Model 2, Effect of Time and Adaptive CER Strategy Use: Coefficients and inferential statistics for Model 2 are shown in Table 6. These outcomes are also illustrated in Fig. 3. For depression, there was a main effect of adaptive CER strategy use ($B = -.05$ [−.07, −.03], $P < .001$, $d = -.48$, BF > 100) but no significant interaction between adaptive CER strategy use and time ($B = -.01$ [−.03, .01], $P = .441$, $d = -.12$, BF = .14). Therefore, greater use of adaptive CER strategies was associated with lower depression, irrespective of time. For anxiety, there was also a main effect of adaptive CER strategy use ($B = -.04$ [−.05, −.02], $P = .002$, $d = -.30$, BF > 100) but, again, no significant interaction between adaptive CER strategy use and time ($B = .00$ [−.02, .02], $P = .876$, $d = .03$, BF = .12). The significant effect of mental health diagnosis reported in Model 1 remained significant in both the depression ($B = -.71$ [−.98, −.44], $P < .001$, $d = -.43$) and anxiety models ($B = -.72$ [−1.00, −.45], $P < .001$, $d = -.41$). The main effect of age reported in Model 1 remained significant for anxiety ($B = -.01$ [−.02, −.00], $P = .004$, $d = -.28$) but was no longer a significant predictor of depression ($B = -.01$ [−.01, −.00], $P = .137$, $d = -.18$).

Model 3, Effect of Time, Adaptive CER Strategy Use and Sleep Quality: Coefficients and inferential statistics for Model 3 are shown in Table 7. These outcomes are also illustrated in Fig. 4. The significant effect of adaptive CER strategy use on depression reported in Model 2 remained significant in this expanded model ($B = -.03$ [−.05, −.01], $P = .002$, $d = -.31$). However, the significant effect of adaptive CER strategy use on anxiety reported in Model 2 was no longer significant ($B = -.02$ [−.04, −.00], $P = .180$, $d = -.17$). There was a main effect of sleep quality on both depression ($B = .21$ [.18, .24], $P < .001$, $d = 1.17$, BF > 100) and anxiety ($B = .19$ [.15, .22], $P < .001$, $d = .93$, BF > 100), such that higher sleep quality was associated with lower

Table 6 – Model 2 coefficients with 95% confidence intervals. Model 2 included participant variables (age, biological sex and mental health diagnosis), time (period during which self-reported depression or anxiety responses were collected) and adaptive CER strategy use. Separate models were run for depression (PHQ-9) and anxiety (GAD-7). Statistically significant coefficients are shown in bold.

	PHQ-9[a]			GAD-7[a]		
	B [CIs]	β [CIs]	p	B [CIs]	β [CIs]	p
Intercept	**2.71 [2.60, 2.82]**	−.02 [-.10, .06]	–	**2.63 [2.52, 2.74]**	.01 [-.06, .09]	–
Age	−.01 [-.01, -.00]	−.08 [-.16, -.01]	.137	**−.01 [-.02, -.00]**	**−.13 [-.21, -.06]**	**.004**
Biological Sex	−.01 [-.30, .27]	−.00 [-.08, .07]	.989	−.24 [-.53, .06]	−.06 [-.13, .01]	.392
Mental Health Diagnosis	**−.71 [-.98, -.44]**	**−.20 [-.28, -.13]**	**<.001**	**−.72 [-1.00, -.45]**	**−.20 [-.27, -.12]**	**<.001**
Time	**−.25 [-.37, -.14]**	**−.18 [-.26, -.10]**	**<.001**	.04 [-.07, .16]	.03 [-.05, .11]	.777
Adaptive CER Strategy Use	**−.05 [-.07, -.03]**	**−.22 [-.30, -.14]**	**<.001**	**−.04 [-.05, -.02]**	**−.14 [-.21, -.07]**	**.002**
Time X Adaptive CER Strategy Use	−.01 [-.03, .01]	−.05 [-.13, .03]	.441	.00 [-.02, .02]	.01 [-.07, .09]	.876

B = Non-standardised coefficients, β = Standardised coefficients.
[a] PHQ-9 and GAD-7 outcome variables were transformed using the Box–Cox transformation.

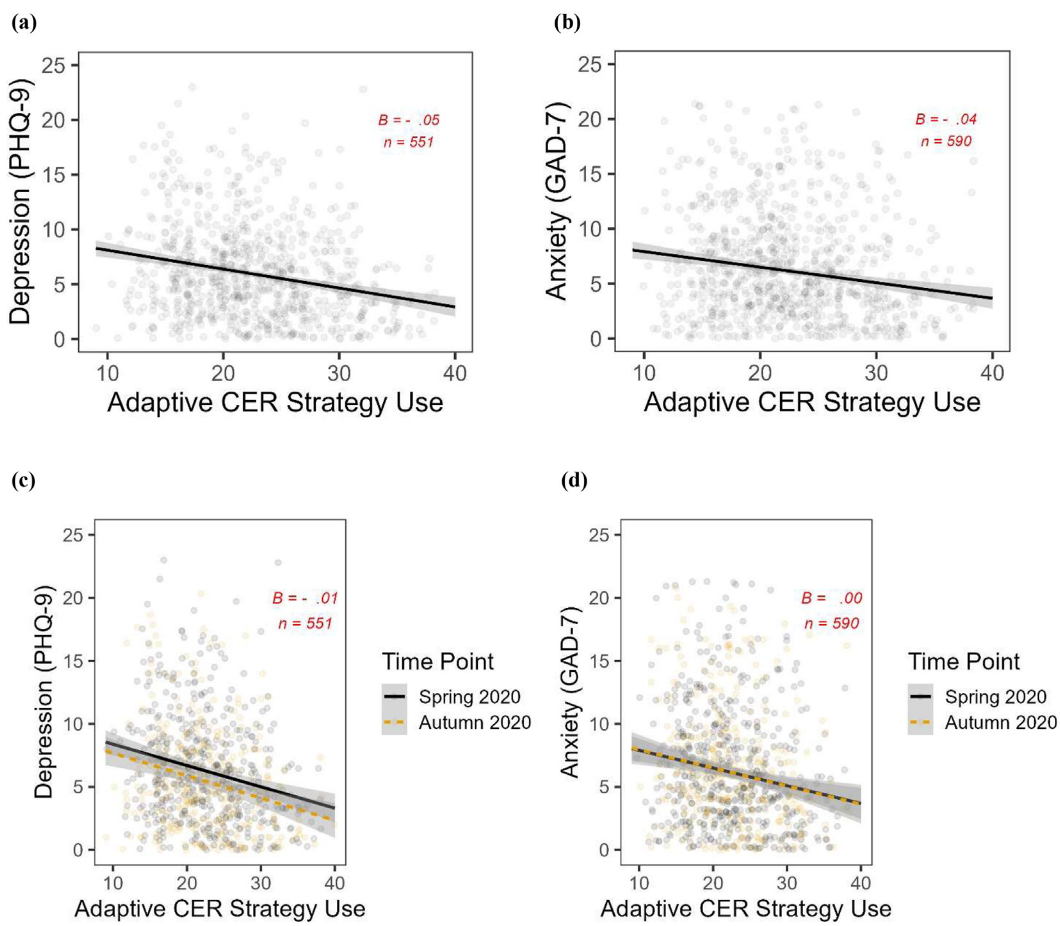

Fig. 3 – Greater use of adaptive CER strategies was significantly associated with (a) lower depression and (b) lower anxiety across both timepoints (Spring and Autumn 2020). There was no significant interaction between adaptive CER strategy use and time for (c) depression or (d) anxiety (black line = Spring 2020; dashed line = Autumn 2020). Grey areas represent 95% confidence intervals. Non-transformed outcomes are shown for visualisation purposes.

depression and anxiety. There was no interaction between sleep quality and time or sleep quality and adaptive CER strategy use on either depression ($B = -.03$ [−.07, .01], $P = .277$, $d = -.16$, $BF = .13$; $B = -.00$ [−.01, .00], $P = .842$, $d = -.03$, $BF = .12$, respectively) or anxiety ($B = -.05$ [−.09, −.01], $P = .065$, $d = -.25$, $BF = 1.88$; $B = .00$ [−.00, .01], $P = .876$, $d = .02$, $BF = .18$, respectively). In addition, there was no significant three-way interaction between time, adaptive CER strategy use and sleep quality on depression ($B = -.00$ [−.01, .00], $P = .439$, $d = -.12$, $BF < .01$) or anxiety ($B = -.00$ [−.01, .00], $P = .821$, $d = -.05$,

Table 7 – Model 3 coefficients with 95% confidence intervals. Model 3 included participant variables (age, biological sex and mental health diagnosis), time (period during which self-reported depression or anxiety responses were collected), adaptive CER strategy use and sleep quality. Separate models were run for depression (PHQ-9) and anxiety (GAD-7). Statistically significant coefficients are shown in bold.

	PHQ-9[a]			GAD-7[a]		
	B [CIs]	*β* [CIs]	*p*	*B* [CIs]	*β* [CIs]	*p*
Intercept	**2.70 [2.61, 2.79]**	−.03 [-.09, .04]	-	**2.64 [2.54, 2.74]**	.02 [-.05, .09]	–
Age	**−.01 [-.01, -.00]**	**−.11 [-.18, -.04]**	**.007**	**−.01 [-.02, -.01]**	**−.16 [-.23, -.09]**	**<.001**
Biological Sex	.02 [-.23, .27]	.01 [-.06, .07]	.942	−.18 [-.45, .09]	−.04 [-.11, .02]	.604
Mental Health Diagnosis	**−.45 [-.69, -.21]**	**−.13 [-.20, -.06]**	**.002**	**−.51 [-.77, -.25]**	**−.14 [-.21, -.07]**	**.001**
Time	**−.27 [-.39, -.15]**	**−.19 [-.27, -.10]**	**<.001**	.04 [-.08, .16]	.03 [-.05, .11]	.777
Adaptive CER Strategy Use	**−.03 [-.05, -.01]**	**−.13 [-.20, -.06]**	**.002**	−.02 [-.04, -.00]	−.08 [-.15, -.01]	.180
Sleep Quality	**.21 [.18, .24]**	**.48 [.41, .54]**	**<.001**	**.19 [.15, .22]**	**.40 [.33, .47]**	**<.001**
Time X Adaptive CER Strategy Use	−.02 [-.04, .00]	−.07 [-.15, .02]	.277	.00 [-.02, .02]	.00 [-.08, .08]	.997
Time X Sleep Quality	−.03 [-.07, .01]	−.07 [-.15, .02]	.277	−.05 [-.09, -.01]	−.10 [-.18, -.02]	.065
Adaptive CER Strategy Use X Sleep Quality	−.00 [-.01, .00]	−.01 [-.08, .06]	.842	.00 [-.00, .01]	.01 [-.06, .08]	.876
Time X Adaptive CER Strategy Use X Sleep Quality	−.00 [-.01, .00]	−.06 [-.15, .04]	.439	−.00 [-.01, .00]	−.02 [-.10, .06]	.821

B = Non-standardised coefficients, *β* = Standardised coefficients.
[a] PHQ-9 and GAD-7 outcome variables were transformed using the Box–Cox transformation.

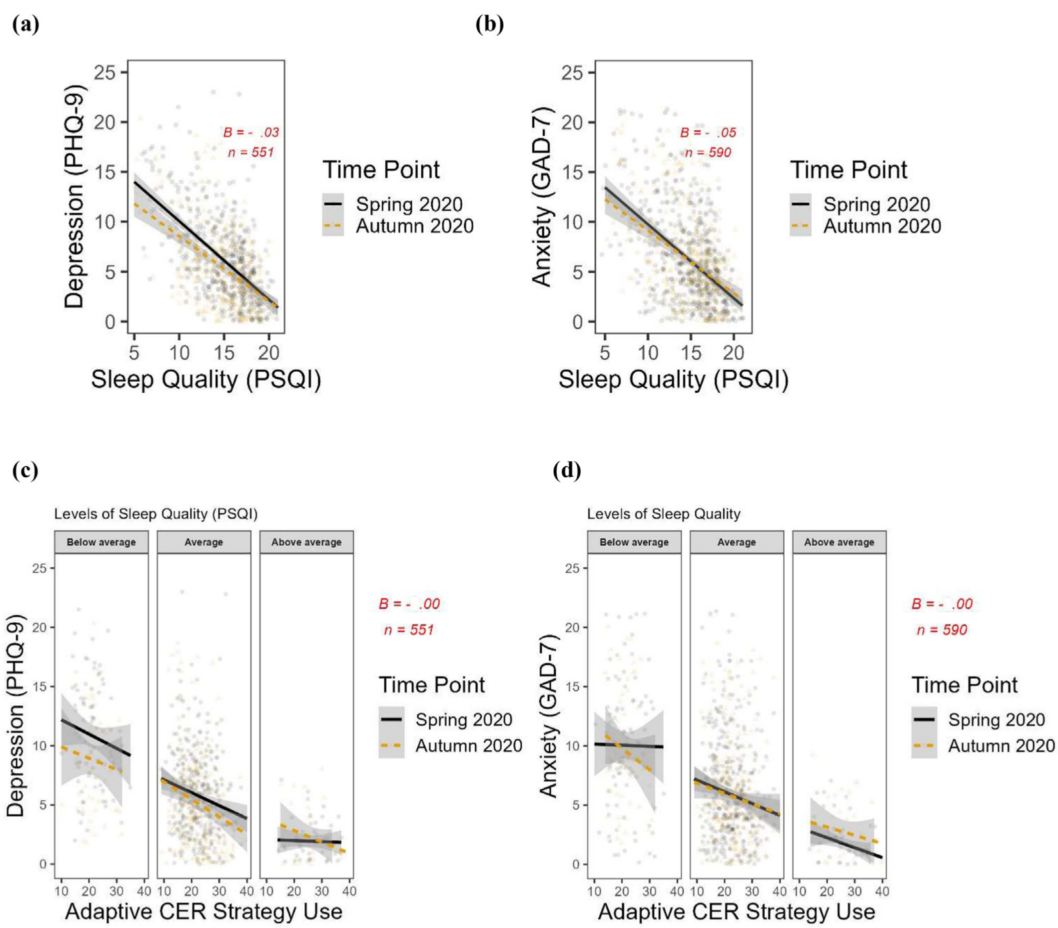

Fig. 4 – PSQI scores have been inverted for visualisation purposes such that higher scores represent higher quality sleep. Higher sleep quality was significantly associated with (a) lower depression and (b) anxiety over time (black line = Spring 2020; dashed line = Autumn 2020). There was no significant interaction between adaptive CER strategy use, sleep quality and time on either (c) self-reported depression or (d) anxiety. Data are plotted at different levels of sleep quality (mean and ± 1 SD). Grey areas represent 95% confidence intervals. Non-transformed outcomes are shown for visualisation purposes.

BF < .01). The significant effects of mental health diagnosis reported in Model 2 remained significant for depression ($B = -.45$ [−.69, −.21], $P = .002$, $d = -.30$) and anxiety ($B = -.51$ [−.77, −.25], $P = .001$, $d = -.31$). Age was also a significant predictor of depression ($B = -.01$ [−.01, −.00], $P = .007$, $d = -.28$) and anxiety ($B = -.01$ [−.02, −.01], $P < .001$, $d = -.37$) in this expanded model.

3.2. *Exploratory analyses*

Although our primary objective was to investigate the influence of adaptive CER strategies and sleep quality on mental health outcomes, we also conducted several exploratory analyses. First, given that poor sleep quality has been shown to increase the use of maladaptive CER strategies (Latif, Hughes, & Bendall, 2019), we also investigated the influence of maladaptive CER strategies and sleep quality on depression and anxiety. Second, because higher levels of depression and anxiety have been reported among Black, Hispanic and Asian communities (as compared to White communities) during the COVID-19 pandemic (Czeisler et al., 2020; Wu, Qian, & Wilkes, 2021), we explored the influence of race in our models. Moreover, because we included participants with and without a current mental health diagnosis in our main analysis, we ran an exploratory analysis to examine whether our findings differed when excluding individuals with a diagnosed mental health disorder. Finally, to determine how people's experience of the pandemic influenced our findings, we ran our models again but only included individuals who reported that COVID-19 had, on the whole, had a negative impact on their lives. We report these findings in the Supplementary Results.

4. Discussion

Previous research has suggested that the mental health benefits of using adaptive CER strategies are contingent on good quality sleep (Mauss et al., 2013; Parsons et al., 2021; Tamm et al., 2019; Zhang et al., 2019). We tested this possibility by investigating whether mental health outcomes arising during a prolonged period of stress (the COVID-19 pandemic) were dependent on adaptive CER strategy use and sleep quality, as well as the interaction of these predictors. We found that greater use of adaptive CER strategies and higher levels of sleep quality were independently associated with lower levels of depression and anxiety. However, only sleep quality was a significant predictor of self-reported anxiety in our final model. The benefits of adaptive CER strategy use for depression were not influenced by naturally varying levels of sleep quality.

The results of our baseline model indicate that depression decreased significantly from Spring to Autumn 2020, as observed in previous work (Fields et al., 2021; Rodriguez-Seijas et al., 2020). However, in contrast to earlier findings (Carr et al., 2022; Fancourt et al., 2020; Kujawa et al., 2020; O'Connor et al., 2020; Velden et al., 2021), anxiety did not significantly change across the same time period. The uncertainty surrounding COVID-19 during the Spring and Autumn of 2020 (e.g. job insecurity, new COVID-19 variants, lack of an approved vaccine) might have contributed to sustained anxiety symptoms. Further support for this possibility comes from evidence that anxiety was persistently worse across the first-year of the COVID-19 pandemic, as compared to before, even when lockdown measures were eased (Patel et al., 2022). It is nevertheless important to note that anxiety data was collected only once at each of the Spring and Autumn timepoints, whereas depression data was collected several times across both timepoints, meaning that the trajectory of mental health outcomes might be better captured in the depression dataset.

Greater use of adaptive CER strategies was associated with lower depression and anxiety in Model 2, supporting hypotheses 1a and 1b. This association was independent of time, demonstrating a stable relationship between adaptive CER strategy use and mental health outcomes. Our findings are well aligned with those reported in previous studies (Aldao & Nolen-Hoeksema, 2010; Cardi, Albano, Gentili, & Sudulich, 2021; Dimanova, Borbás, Schnider, Fehlbaum, & Raschle, 2022; Domaradzka & Fajkowska, 2018; Garnefski et al., 2002; Jungmann & Witthöft, 2020; Martin & Dahlen, 2005; Muñoz-Navarro, Malonda, Llorca-Mestre, Cano-Vindel, & Fernández-Berrocal, 2021; Wang et al., 2021; Waterschoot et al., 2022) and have potentially important clinical implications (e.g. deploying adaptive CER strategies could be utilised as a preventative measure when confronted with real-world emotional turmoil). It has been suggested that adaptive CER strategy use promotes wellbeing by reducing negative affect (Cardi et al., 2021), potentially via similar mechanisms to those underpinning the downregulation of intrusive thoughts (Engen & Anderson, 2018; Harrington & Cairney, 2021). Maintaining such self-directed and adaptive inputs to one's affective composition might be particularly important for psychological wellbeing when enduring chronic periods of stress. It should be noted, however, that adaptive CER strategy use was not a significant predictor of anxiety when we added sleep quality to our final model. This is in keeping with prior work showing that cognitive regulation of emotion may be less crucial in the context of anxiety than depression (Domaradzka & Fajkowska, 2018).

Higher levels of sleep quality were associated with lower depression and anxiety, supporting hypotheses 2a and 2b. This association was also independent of time, suggesting a stable relationship between sleep quality and mental health outcomes. Our findings are in keeping with previous work (Alqahtani et al., 2022; Baglioni et al., 2010; Bi & Chen, 2022; Franceschini et al., 2020; Freeman et al., 2017; French, Mortensen, & Timming, 2022; Randall, Nowakowski, & Ellis, 2019; Scott et al., 2021; Varma, Burge, Meaklim, Junge, & Jackson, 2021) and highlight sleep's role in maintaining affective wellbeing (Bower, Bylsma, Morris, & Rottenberg, 2010). Sleep supports cognitive processes that often go awry in mood disorders, such as emotion regulation and memory consolidation (Ashton et al., 2020; Cairney, Lindsay, Paller, & Gaskell, 2018; Fairholme & Manber, 2015; Guttesen et al., 2023; Harrington et al., 2021; Palmer & Alfano, 2017), which might represent mechanistic pathways linking sleep quality to mental health. It is noteworthy that many of the pandemic-related sources of sleep disruption (e.g. reduced outdoor activity and increased screen time; Landry, Bergstrom, Salazar, & Turner, 2021; Price, 2022) would have remained fairly constant during the study period, potentially nullifying any impact of time in our models.

There was no two-way interaction between sleep quality and adaptive CER strategy use, and no three-way interaction between sleep quality, adaptive CER strategy use and time for either depression or anxiety, refuting hypotheses 3a and 3b. Similar patterns have been observed in previous work; for example, insomnia and emotion dysregulation both predict symptom severity in depression and anxiety disorder, but show no interaction (Fairholme et al., 2013). Together with our other findings, these null effects suggest that high sleep quality and adaptive CER strategies independently support resilience to depression, as the association between adaptive CER strategy use and depression was similar at different levels of sleep quality. The same cannot be said for anxiety, however, as adaptive CER strategy use was not a significant predictor of anxiety outcomes in this final model that accounted for sleep quality. Nevertheless, because the observed effect sizes for the interactions in Models 2 and 3 were considerably smaller than the effect sizes for which the study was powered to detect, it is possible that the dataset was underpowered to detect any interaction effects, should they have existed.

It is worth noting that our data revealed a significant correlation between sleep quality and adaptive CER strategy use; whereby greater use of adaptive CER strategies was associated with higher sleep quality. Although there may be a bidirectional relationship between these variables, the observed correlation is aligned with prior work showing that poor quality sleep can negatively impact on people's ability to deploy adaptive CER strategies effectively (Mauss et al., 2013; Parsons et al., 2021; Tamm et al., 2019; Zhang et al., 2019), potentially via the disruption of cognitive control processes supported by the prefrontal cortex (Mauss et al., 2013). Overall, these data suggest that good quality sleep is tightly linked to the tendency to deploy adaptive CER strategies, but these variables do not have a synergistic influence upon depression or anxiety outcomes.

Each of our models controlled for age, biological sex and mental health diagnosis. We found that age was a significant predictor of mental health outcomes, with older adults experiencing fewer depression and anxiety symptoms than younger adults. Recent work on the same dataset has shown that younger adults felt more inconvenienced and frustrated with stay-at-home orders than older adults, resulting in a greater mental health burden (Cunningham, Fields, Garcia, et al., 2021; Fields et al., 2021). We also found that an existing diagnosis of a mental health condition (versus no diagnosis) was associated with higher levels of depression and anxiety, as observed previously (Fancourt et al., 2020; Gémes et al., 2022; Jia et al., 2022). Contrary to evidence that females are more likely to experience depression and anxiety than males (Carr et al., 2022; Fancourt et al., 2020; French et al., 2022; Jia et al., 2022), there was no effect of biological sex on depression or anxiety outcomes in our dataset. It is important to note, however, that our sample was predominantly female (82.9% for both depression and anxiety), which may have precluded any effect of biological sex from emerging (should one exist in the context of depression and anxiety outcomes during the COVID-19 pandemic).

This is the first study to investigate the ways in which adaptive CER strategies and sleep quality influence mental health outcomes when experiencing a real-world, chronic stressor. Nevertheless, there were several limitations with our study design that might have contributed to the null effects observed in our final model. First, we relied on subjective reports to index emotion regulation and sleep quality. Previous research has shown that discrepancies exist between affective responses assessed subjectively and objectively (Zhang et al., 2019), and self-reported sleep quality is often lower than that indicated by objective measures of sleep continuity or wake-after-sleep-onset (Buysse et al., 2008; Grandner, Kripke, Yoon, & Youngstedt, 2006). Future research examining sleep and mental health in the context of real-world chronic stressors can address this limitation by combining objective and subjective assessments of sleep quality and emotion regulation, potentially through the use of wearables tracking sleep and physiological arousal (e.g. heart rate variability). Relatedly, in the data we had available, adaptive CER strategy use and sleep quality were measured only once (May 2020), whereas depression and anxiety were measured twice (Spring and Autumn 2020). Consequently, we were unable to assess any changes in adaptive CER strategy use or sleep quality that may have arisen during the initial months of the pandemic.

Second, although our decision to use a composite measure of adaptive CER strategy use allowed us to investigate how sleep quality and generalised positive thought processes influenced mental health outcomes, it prevented us from determining whether a specific strategy (or smaller combination of strategies) was particularly effective in this regard. For example, some studies have shown that positive reappraisal is a strong predictor of depression and anxiety (Aldao & Nolen-Hoeksema, 2010; Cardi et al., 2021; Dimanova et al., 2022; Garnefski et al., 2002; Martin & Dahlen, 2005; Muñoz-Navarro et al., 2021), while others have indicated that resilience to mental health problems is supported by a finely-tuned balance of adaptive and maladaptive strategies (Waterschoot et al., 2022). Our pre-registered analyses were unable to address whether specific (or different combinations of) adaptive CER strategies interact with sleep quality to support affective wellbeing and this will be an important endeavour for future work.

A more general limitation of our study was the lack of socio-demographic diversity in the data that we had available. Participants were predominantly female, white, well-educated individuals all residing in the United States of America (Cunningham, Fields, & Kensinger, 2021). As a result, we were unable to provide appropriate control for other relevant covariates that may have influenced depression and anxiety (e.g. socioeconomic status). Furthermore, because the data were collected in an online setting, only individuals with access to a PC, tablet or smartphone were able to participate. Despite the diversity in scores on the self-report measures, our findings cannot be easily generalised to different societies, environments and cultures, and replication across broader populations will be a crucial next step.

Finally, the COVID-19 pandemic was a very unique and complex stressor, which was associated with a number of factors that may have affected depression and anxiety symptoms (e.g. job security, living situation). It is therefore difficult to draw comparisons between the impacts of COVID-19 and other prolonged stressors on mental health outcomes.

In conclusion, we found that, during the initial months of the COVID-19 pandemic, greater use of adaptive CER strategies was associated with lower depression, whereas higher sleep quality was associated with lower depression and anxiety. The relationship between adaptive CER strategy use and mental health outcomes was not contingent on good quality sleep, however. Building on a large body of laboratory-based research, our findings call attention to the potential transdiagnostic benefits of targeting sleep quality and adaptive CER strategy use when enduring chronic periods of emotional hardship.

Declaration of competing interest

The authors of this article declare that they have no conflict of interest.

Credit author statement

Emma C. Sullivan: Conceptualisation, Formal Analysis, Visualization, Writing - Original Draft. **Emma James**: Formal Analysis, Writing- Review & Editing. **Lisa-Marie Henderson**: Conceptualisation, Writing- Review & Editing. **Cade McCall**: Conceptualisation, Writing- Review & Editing. **Scott A. Cairney:**Conceptualisation, Writing- Review & Editing, Supervision.

Open practices section

The study in this article earned Preregistered badge for transparent practices. The data files and scripts for the preregistered and exploratory analyses can be found at https://osf.io/x952b/

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Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cortex.2023.06.001.

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