ORIGINAL ARTICLE

Rumination as a Mechanism of the Longitudinal Association Between COVID-19-Related Stress and Internalizing Symptoms in Adolescents

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Abstract

The current prospective longitudinal study evaluated brooding rumination as an intervening mechanism of the association between COVID-19-related stress and internalizing symptoms during the first year of the pandemic. Attention-deficit/hyperactivity disorder (ADHD) status and adolescent sex were tested as moderators of the indirect effect. Adolescents with and without ADHD ($N = 238$; M age = 16.74) completed rating scales of COVID-19 stress and both adolescents and parents completed ratings scales of internalizing symptoms in May/June 2020 (T1). In October/November 2020 (T2), adolescents reported on their brooding rumination. Adolescents and parents reported on internalizing symptoms again in March/April 2021 (T3). Covariates included participant characteristics and baseline symptoms. T1 self-reported COVID-19-related stress was associated with increased T3 self-reported anxiety ($ab = 0.10$), self-reported depression ($ab = 0.07$), and parent-reported depression ($ab = 0.09$) via T2 brooding rumination. The indirect effect did not differ for adolescents with and without ADHD or for female and male adolescents. Brooding rumination may be one mechanism to target to promote the mental health adjustment of adolescents during periods of high stress of the COVID-19 pandemic and future stressors.

Keywords COVID-19 · Stress · Rumination · Depression · Anxiety · Adolescence

Introduction

The COVID-19 pandemic represents a substantial source of ongoing psychosocial disruptions for youth and families. Starting in early 2020, families encountered closures to schools and businesses, stay at home orders, mask mandates, social distancing measures, and ongoing exposure to infection threat [1]. Unsurprisingly, elevated mental health difficulties are recognized as a major public health concern during the pandemic, especially among at-risk groups like adolescents [2]. Despite a body of literature documenting increased anxiety and depressive symptoms in adolescents during early phases of the COVID-19 pandemic [3], prospective longitudinal studies throughout the course of the pandemic are limited [4–6]. Further, although there have been recent efforts at understanding risk and resilience factors that may explain variability in mental health outcomes, it is largely unknown which factors might explain the association between COVID-19-related stress and heightened internalizing symptoms. Evaluating risk factors for the long-term impact of pandemic related stress and mental health in adolescents is a clear research and clinical priority to inform

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improved prevention, intervention, and clinical care [4, 7]. The current study aims to examine COVID-19-related stress and internalizing symptoms across the first year of the pandemic, and to test brooding rumination as a mechanism linking stress to increased internalizing symptoms.

COVID-19 Stress and Internalizing Symptoms

Adolescents have encountered many disruptions as a result of the COVID-19 pandemic, including ongoing fears of infection, multiple school closures and transitions to and from virtual learning, disrupted social activities, family financial insecurity, and increased household stress [5]. As these changes have interfered with autonomy and peer connectedness in adolescence, an already vulnerable developmental period of increased mental health difficulties [5, 8], heightened rates of depression and anxiety symptoms during the COVID-19 pandemic are unsurprising [2, 5, 6, 9]. COVID-19-related stressors, such as family stress, inconsistent schedules, and online schooling difficulties, have been specifically linked to greater mental health symptoms [7, 10, 11]. These cross-sectional findings have been replicated in a few short-term longitudinal studies documenting acute mental health effects during the COVID-19 pandemic [12, 13]. However, our understanding of the long-term impact beyond immediate restrictions in the first few months of the pandemic are scarce [4]. As an exception, Liu et al. [5] evaluated trajectories of depressive symptoms in a community-based sample of adolescents before, shortly after (e.g., 6 to 12 weeks), and during (e.g., around 8–9 months) the pandemic. Although findings demonstrated adolescent sex differences in the acute effects of the pandemic, both adolescent boys and girls reported elevated depressive symptoms 8 to 9 months after shutdown orders [5].

The extant literature clearly documents the acute mental health effects of COVID-19-related concerns on adolescent mental health. As the pandemic continues to persist and evolve, it is critical to better understand the long-term impact of the pandemic. Additionally, as researchers and clinicians have turned to identifying risk and protective factors of adolescent adjustment [7], evaluating intervening factors that might explain the temporal relation of COVID-19 stress with heightened internalizing symptoms is of clear importance.

Brooding Rumination as an Intervening Mechanism

Brooding rumination is an important mechanism to evaluate when considering intervening factors that might explain the prospective association between COVID-19 stress and increased internalizing symptoms. Rumination refers to a cognitive strategy characterized by perseveration on negative events, causes and consequences of negative events, and affective states [14]. Research identifies reflective (e.g.,

actively problem-solving and attempting to understand current difficulties) and brooding rumination (e.g., passively reflecting on symptoms) as two subtypes of rumination [15]. Brooding rumination has been identified as a key transdiagnostic mechanism linking environmental stress to multiple forms of internalizing psychopathology symptoms [14, 16–18].

Indirect evidence points to a potential role of rumination as an individual factor augmenting risk for mental health increases during the COVID-19 pandemic. In two cross-sectional studies of adults, self-reported rumination mediated the relation between COVID-19 stressors and mental health symptoms [19] and between perceived stress and decreased life satisfaction [20]. In a cross-sectional sample of adolescents, self-reported rumination mediated the relation between negative affect and intolerance of uncertainty with depressive symptoms [21]. Finally, two studies examined rumination as a predictor of mental health symptom change during the pandemic. In a community-based sample of 53 youth, self-reported rumination during COVID-19 was prospectively associated with increased anxiety and depression symptoms [22]. In a second study of 84 youth, self-report ratings of socio-emotional vulnerability, which included trait anxiety, rumination, and intolerance of uncertainty, predicted increased anxiety and post-traumatic stress symptoms at different phases of the COVID-19 pandemic [23]. Although these studies did not assess specific types of rumination, like brooding, findings point to the role of ruminative processes as a mechanism of the relation between stress and mental health outcomes during the COVID-19 pandemic.

As a result of ongoing COVID-19 stress, adolescents may become more vigilant for threat, experience helplessness, and spend more time isolated from peers, all resulting in opportunities for ruminative thinking [16, 24]. In turn, excessive brooding rumination may enhance negative affect, perpetuate negative and perseverative thinking, and disrupt problem-solving strategies, thereby increasing symptoms of anxiety and depression [14, 19].

Possible Moderation by ADHD Group Status

Although many adolescents are at increased risk for the negative impact of COVID-19 stress as documented above, adolescents with pre-existing mental health and neurodevelopmental conditions represent a vulnerable group. Specifically, adolescents with attention-deficit/hyperactivity disorder (ADHD) have well-documented adjustment challenges during the COVID-19 pandemic and increased rates of internalizing comorbidity [8, 25]. For instance, adolescents with ADHD may be more negatively impacted by the reduction in structured routines, in-person social relationships, and experience increased emotional distress. In turn, adolescents may

experience increased ruminative pattern of though and internalizing symptoms. We used a sample of adolescents with and without ADHD to test whether ADHD status results in unique risk for associations between COVID-19 stress, brooding rumination, and internalizing psychopathology.

Current Study

The current prospective longitudinal study seeks to build on the extant literature by testing brooding rumination as an intervening mechanism of the relation between COVID-19 stress and internalizing symptoms in adolescents. Specifically, we tested whether self-reported COVID-19 stress would be indirectly associated with both parent- and self-reported ratings of internalizing symptoms through self-reported brooding rumination. Consistent with literature linking stress to greater brooding rumination [21, 26] and brooding rumination to increased mental health difficulties [16, 22], we expected brooding rumination to emerge as a significant indirect effect of the link between COVID-19-related stress and increased internalizing symptoms. Further, as mentioned above, we included a sample of adolescents with and without ADHD to test whether the associations between COVID-19 stress, brooding rumination, and internalizing symptoms would be stronger for adolescents with ADHD. Due to increased risk of the negative impact of COVID-19 stress and related changes, we anticipated the indirect effect of COVID-19 stress on internalizing symptoms via brooding rumination to be stronger for adolescents with ADHD than for adolescents without ADHD. Finally, consistent with studies highlighting increased COVID-19 stress and internalizing symptoms in female adolescents [5, 7], we tested whether the magnitude of the indirect effect would differ in male and female adolescents. We hypothesized that the indirect effect of COVID-19 stress on internalizing symptoms through increased brooding rumination would be stronger for female adolescents compared to male adolescents.

Methods

Participants

Participants were 238 adolescents (44.5% female) between the ages of 15 and 17 years. At the initial evaluation of the prospective study before COVID-19, adolescents underwent comprehensive evaluation for ADHD (118 adolescents were diagnosed with ADHD; 120 comparison sample). Adolescent self-reported race/ethnicity was White (82%), Biracial/Multiracial (7%), Black (6%), Asian (4%) and 1% as identifying as another race. Approximately 19% of families reported an annual family income below the 2019 median household income. Further description of sample procedures are available in supplemental material.

Procedures

Participants from the initial longitudinal study were 302 adolescents ($n = 162$ with ADHD) between the ages of 12 and 14 years. This study was approved by the institutional review boards (IRB) at Cincinnati Children's Hospital Medical Center and Virginia Commonwealth University. School staff at middle schools around Cincinnati, Ohio and Richmond, Virginia were provided with recruitment materials to distribute to families (letters/flyers to students, newsletters, e-mail blasts). Parents contacted the research staff in response to recruitment materials and, after meeting general phone screening criteria (e.g., enrollment in eight grade), were invited for the initial visit. At this visit, the adolescent and parent received a comprehensive assessment, with inclusion criteria including: Full Scale IQ > 80 on *Weschler Abbreviated Scale of Intelligence, Second Edition* (WASI-II) and meeting criteria for ADHD or comparison group. Exclusion criteria were: (1) having a previous diagnosis of or meeting criteria for autism spectrum disorders, bipolar disorder, a dissociative disorder, or a psychotic disorder; (2) previous diagnosis of an organic sleep disorder (e.g., obstructive sleep apnea, narcolepsy, restless leg syndrome, periodic limb movement disorder) according to parent report during the initial phone screen, (3) families who do not have sufficient English language to complete study materials, and (4) not meeting criteria for either the ADHD or comparison groups as described next.

Adolescents were evaluated for ADHD at the initial visit in accordance with the Fifth Edition of the Diagnostic and Statistical Manual for Mental Disorders (DSM-5) criteria. The parent version of the *Children's Interview for Psychiatric Syndromes* (P-ChIPS) [27] was used to determine adolescent eligibility for the ADHD group. Adolescents were required to meet all DSM-5 criteria for either ADHD Combined Presentation or Predominately Inattentive Presentation according to parent-report on the P-ChIPS. Adolescents participated in the comparison group if parents endorsed ≤ 4 symptoms of both inattention and hyperactivity/impulsivity. Parents provided written consent and adolescents provided assent at the first visit.

The current study used data from three timepoints of the longitudinal COVID-19 follow-up study to the larger initial study examining adjustment in adolescents with and without ADHD [28]. Of the 302 total participants enrolled in the initial study, 262 provided permission to be contacted for follow-up data collection. Of these, 238 families participated in the COVID-19 follow-up study and provided data collected online via REDCap at three timepoints: between May 15 and June 14, 2020 (T1), October 15 and November 19, 2020

(T2), and March 15 and April 14, 2021 (T3). These 238 participants did not differ from the 24 participants who did not participate in the COVID-19 follow-up study on baseline demographic factors (e.g., sex, race), ADHD symptoms, internalizing symptoms, or overall impairment ($ps > 0.05$).

Measures

COVID-19 Adolescent Symptom & Psychological Experience Questionnaire (CASPE)

The CASPE [29] is an adolescent self-report measure assessing experiences and impacts of COVID-19. On a 5-point scale (1 = *very slightly or not at all*, 2 = *slightly*, 3 = *moderately*, 4 = *quite a bit*, 5 = *extremely*), adolescents were instructed to report on the frequency of 13 emotional reactions reflecting stress "because of the COVID-19 outbreak." Each of the 13 items (e.g., anxious, concerned, frustrated, hopeless, overwhelmed, distressed) was rated individually and a mean score across the items was created, with higher scores indicating greater COVID-19 stress. Internal consistency in the current study was $\alpha = 0.93$.

Ruminative Responses Scales (RRS)

The RRS [30] consists of 22 items measuring depressive, brooding, and reflective rumination on a 4-point scale (1 = *almost never,* 2 = *sometimes,* 3 = *often*, 4 = *almost always)* [31]. For purposes of the current study, the 5-item brooding rumination subscale was used (e.g., "think why do I always react this way?"). The brooding rumination subscale has strong internal consistency and convergent validity with internalizing domains [15]. Higher scores reflect greater brooding rumination, and the internal consistency score in the current study was $\alpha = 0.82$.

Revised Child Anxiety and Depression Scale (RCADS)

The RCADS was used to measure self and parent report of anxiety and depressive symptoms [32]. The RCADS includes 47 items measuring symptoms of five anxiety subscales (i.e., social phobia, panic disorder, separation anxiety disorder, obsessive compulsive disorder, and generalized anxiety disorder) and one major depressive subscale on a 4-point scale (0 = *never,* 1 = *sometimes,* 2 = *often,* 3 = *always*). The current study assessed parent and self-ratings on the major depressive disorder subscale and total anxiety scale, which is the mean score of the five anxiety subscales. The RCADS has well documented internal consistency and convergence with measures of internalizing symptoms in community [32] and ADHD specific samples of youth [33]. In the present study, internal consistency was strong: self-reported depression $\alpha s = 0.89$ and 0.91 for T1

and T3, respectively; self-reported anxiety $\alpha s = 0.96$ for T1 and T3; parent-reported depression $\alpha s = 0.86$ and 0.85 for T1 and T3, respectively; and parent-reported anxiety $\alpha s = 0.95$ and 0.94 for T1 and T3, respectively.

Demographic Variables

Parents reported on adolescents' biological sex and medication status (0 = not on medication or unsure, 1 = on medication) at T1, and whether the adolescent was in-person or remote at the start of the 2020–2021 academic year (T2).

Analytic Strategy

Zero-order correlations were conducted among demographic factors and primary study variables. Demographic factors significantly associated with either T3 self- or parent-reported depressive or anxiety symptoms were used as covariates. Path analyses and tests of indirect effects were conducted in the *Mplus* statistical software (version 8.1). Manifest variables were used given the sample size, and all models were just identified (DF = 0). We tested four indirect effect models separately, with T1 self-reported COVID-19 stress as the predictor and T2 self-reported brooding rumination as the intervening factor. These four models included T3 self-reported depression, self-reported anxiety, parent-reported depression, and parent-reported anxiety as outcomes. Models controlled for significant demographic factors and baseline depression or anxiety symptoms for each respective model. The direct and indirect effects and their 95% confidence intervals (CI) were calculated using 10,000 bias-corrected bootstrapped sampling estimates [34]. Further, aligning with recommendations on testing the indirect effect even in the absence of a total or direct effect [35], we tested the indirect effect across all models. Finally, in all models, we tested whether the indirect effect was moderated by ADHD group status (0 = comparison, 1 = ADHD) or adolescent sex (0 = male adolescent, 1 = female adolescent).

Results

Bivariate Associations

Table 1 presents zero-order correlations and descriptive statistics between demographic variables and primary study variables. The following demographic factors were correlated with T3 outcomes: adolescent sex, medication status, and ADHD group status and so these variables were used as covariates in the indirect effect models. However, when testing moderated-mediation, adolescent sex and ADHD group status were not treated as covariates when used as moderators. School type was also included as a covariate.

Table 1 Means, standard deviations, and bivariate correlations among study variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Sex	–													
2. Med	0.03	–												
3. Group	− 0.20**	0.48**	–											
4. School	− 0.00	0.01	0.05	–										
5. SR T1 Stress	0.35**	0.15*	− 0.04	− 0.03	–									
6. SR T1 Dep	0.31**	0.18**	0.05	0.11	0.62**	–								
7. SR T1 Anx	0.33**	0.18**	0.01	0.06	0.66**	0.75**	–							
8. PR T1 Dep	0.07	0.30**	0.25*	0.16*	0.26**	0.50**	0.32**	–						
9. PR T1 Anx	0.16*	0.29**	0.18**	0.11	0.29**	0.37**	0.44**	0.71**	–					
10. SR T2 Rumination	0.17*	0.23**	0.11	− 0.07	0.51**	0.56**	0.58**	0.21**	0.25**	–				
11. SR T3 Dep	0.27**	0.12	0.10	0.03	0.40**	0.64**	0.45**	0.39*	0.25**	0.56**	–			
12. SR T3 Anx	0.35**	0.17*	0.09	0.01	0.46**	0.52**	0.60**	0.26**	0.35**	0.64**	0.78**	–		
13. PR T3 Dep	0.12	0.25**	0.22**	0.10	0.29**	0.48**	0.33**	0.73**	0.53**	0.38**	0.54**	0.48**	–	
14. PR T3 Anx	0.28**	0.20**	.17	0.10	0.36**	0.36**	0.43**	0.48**	0.71**	0.35**	0.42**	0.60**	0.66**	–
Mean	–	–	–	–	2.18	0.72	0.58	0.46	0.33	7.72	0.70	0.52	0.44	0.32
SD	–	–	–	–	0.85	0.55	0.46	0.42	0.28	2.77	0.59	0.45	0.39	0.30

For sex, *0* male participant, *1* female participant. For med, *0* no medication, *1* current medication. For group, *0* comparison, *1* ADHD. For school, *0* in-person, *1* = remote. *T1* timepoint 1. *T2* timepoint 2. *T3* timepoint 3. *SR* adolescent self-report. *PR* parent-report. *Stress* COVID-19 stress. *Dep* depression. *Anx* Anxiety

*$p < 0.05$,**$p < 0.01$

Adolescents' race was unrelated to T3 self- or parent-reported outcomes and was thus not included as a covariate in analyses.

Indirect Effect of COVID-19 Stress on Self-Reported Internalizing Symptoms via Brooding Rumination

The first set of analyses tested T1 COVID-19 stress, T2 brooding rumination, and T3 self-reported depression and anxiety symptoms, with results summarized in Fig. 1. In contrast to bivariate correlations, T1 COVID-19 stress was unrelated to T3 self-reported depressive symptoms ($\beta = -0.10$, $p = 0.221$) after controlling for covariates and T1 self-reported depression. Conversely, T1 COVID-19 stress was uniquely associated with greater T2 brooding rumination ($\beta = 0.23$, $p = 0.006$). Adolescent sex, group status, medication status, and school type were unrelated to T2 brooding rumination and T3 self-reported depression. T2 brooding rumination was uniquely associated with T3 self-reported depressive symptoms ($\beta = 0.32$, $p < 0.001$), above and beyond covariates, T1 depression, and T1 COVID-19 stress. Regarding the indirect effect, T1 COVID-19-related stress was associated with increased T3 self-reported depression ($ab = 0.07$, $p = 0.039$, 95% CI [0.010, 0.111]) via T2 brooding rumination, above and beyond adolescent sex, medication status, school type, ADHD group status, and T1 self-reported symptom ratings.

In analyses for self-reported anxiety, T1 COVID-19 stress was unrelated to T3 self-reported anxiety symptoms ($\beta = 0.01$, $p = 0.871$) above and beyond covariates and T1 self-reported anxiety symptoms. Female adolescents reported higher T3 self-reported anxiety ($\beta = 0.15$, $p = 0.019$). Further, above and beyond covariates and T1 self-reported anxiety symptoms, T1 COVID-19 stress remained associated with higher T2 brooding rumination ($\beta = 0.22$, $p = 0.004$), and T2 brooding rumination predicted increases in T3 self-reported anxiety ($\beta = 0.46$, $p < 0.001$). Finally, above and beyond adolescent sex, medication status, school type, ADHD group status, and T1 self-reported symptom ratings, T1 COVID-19-related stress was associated with increased T3 self-reported anxiety ($ab = 0.10$, $p = 0.033$, 95% CI [0.008, 0.113]) via T2 brooding rumination (Table 2).

Indirect Effect of COVID-19 Stress on Parent-Reported Internalizing Symptoms via Brooding Rumination

Next, we evaluated T1 COVID-19 stress, T2 brooding rumination, and T3 parent-reported depression and anxiety symptoms, with results summarized in Fig. 2. In contrast to bivariate correlations, when controlling for key demographic factors and T1 depressive symptoms, T1 COVID-19 stress was unrelated to T3 parent-reported depressive symptoms ($\beta = 0.02$, $p = 0.709$). However, T1 COVID-19 stress was uniquely associated with greater T2 brooding rumination

Fig. 1 Mediation results of T1 COVID-19 stress, T2 brooding rumination, and T3 self-reported depression symptoms (top figure) and anxiety symptoms (bottom figure)
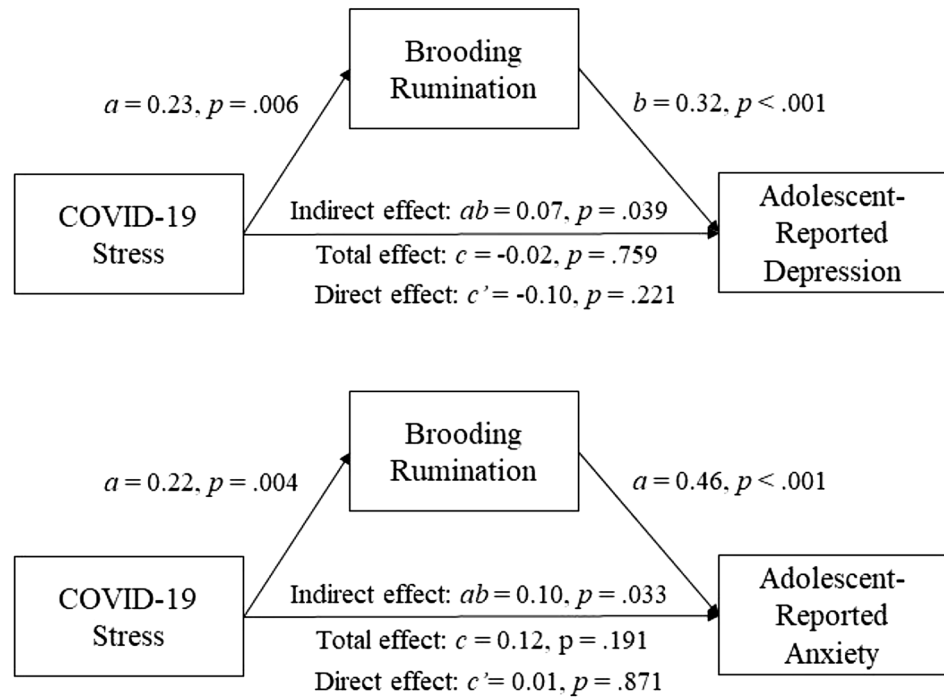
Table 2 Indirect effect results of T1 COVID-19 stress, T2 brooding rumination, and T3 self- and parent-reported depression and anxiety symptoms

Indirect effect	Adolescent-report				Parent-report			
	ab	SE	95% CI	p	ab	SE	95% CI	p
T1 Stress → T2 Rumination → T3 Depression	0.074	0.026	0.010, 0.111	0.039	0.094	0.036	0.014, 0.080	0.009
T1 Stress → T2 Rumination → T3 Anxiety	0.102	0.048	0.008, 0.113	0.033	0.060	0.031	0.000, 0.045	0.057

All analyses also controlled for ADHD group status, sex, T1 medication status, school type (remote vs. in-person), and baseline symptoms ratings. Standardized *ab* indirect effect and unstandardized confidence intervals are presented

($\beta = 0.48$, $p < 0.001$). Adolescents with ADHD had higher T3 parent-reported depressive symptoms ($\beta = 0.13$, $p = 0.022$). Further, T2 brooding rumination was uniquely associated with T3 parent-reported depressive symptoms ($\beta = 0.20$, $p = 0.003$), after controlling for demographic factors and T1 parent-reported depression. The indirect effect of T1 COVID-19 stress on T3 parent-reported depression via T2 brooding rumination emerged as significant ($ab = 0.09$, $p = 0.009$, 95% CI [0.014, 0.080]) (Table 2).

In contrast to bivariate correlations, T1 COVID-19 stress was unrelated to T3 parent-reported anxiety symptoms ($\beta = 0.08$, $p = 0.124$) when controlling for adolescent sex, ADHD group status, medication status, and T1 parent-reported anxiety symptoms. Similar to the self-reported findings, female adolescents had higher T3 parent ratings of

anxiety ($\beta = 0.163$, $p = 0.003$). Additionally, T1 COVID-19 stress remained associated with higher T2 brooding rumination ($\beta = 0.47$, $p < 0.001$), and T2 brooding rumination predicted increases in T3 parent-reported anxiety ($\beta = 0.13$, $p = 0.043$), controlling for covariates and T1 anxiety symptoms. However, and in contrast to previous results, the indirect effect for T3 parent-reported anxiety was nonsignificant ($p = 0.057$).

Moderated Indirect Effect for ADHD Group Status and Adolescent Sex

Finally, we explored whether the indirect effects were moderated by ADHD group status (0 = comparison, 1 = ADHD) or whether the magnitude of the indirect effect differed for

Fig. 2 Mediation results of T1 COVID-19 stress, T2 brooding rumination, and T3 parent-reported depression symptoms (top figure) and anxiety symptoms (bottom figure)
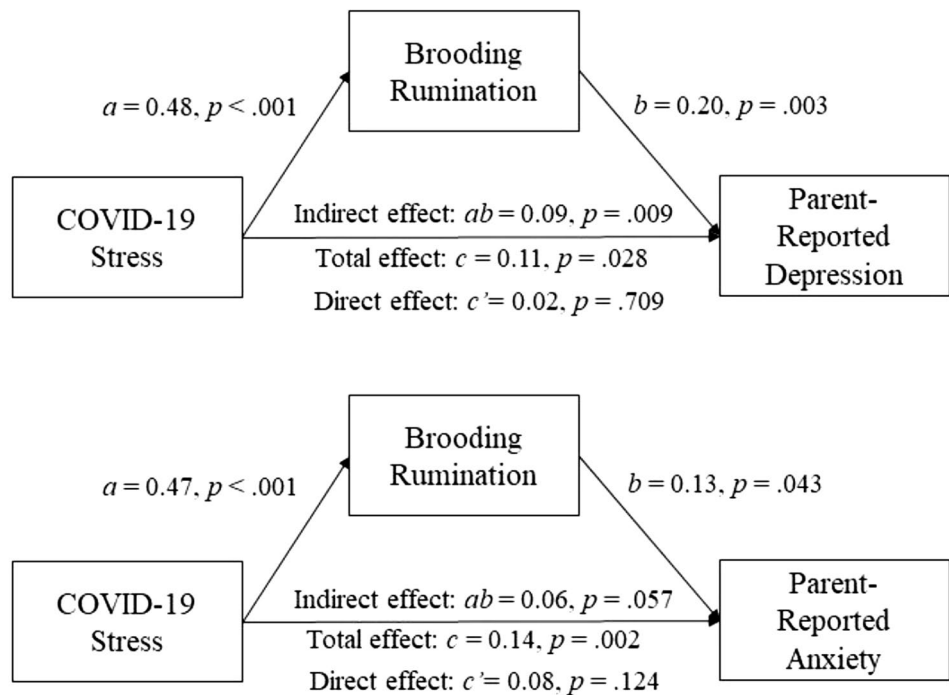
male and female adolescents. Across all models for adolescent and parent ratings of mental health symptoms, neither ADHD group status nor adolescent biological sex moderated the indirect effect of COVID-19 stress, rumination, and self- and parent-reported internalizing symptoms ($ps > 0.05$).

Discussion

As the COVID-19 pandemic continues to unfold and interfere with the adjustment and well-being of adolescents, it is critical to identify potential factors that may explain risk for mental health outcomes. The current study evaluated brooding rumination as a mechanism of the prospective association between COVID-19 stress and internalizing symptoms in adolescents with and without ADHD. Findings build on prior studies linking rumination to internalizing symptoms [21, 22] and, to our knowledge, are the first to identify brooding rumination as an intervening mechanism of the prospective association of adolescents' self-reported COVID-19 stress and increased internalizing symptoms. Although COVID-19 was significantly correlated with depressive and anxiety symptoms 1 year later, the direct effect when controlling for demographic and baseline symptoms was unrelated. However, we continued to test the indirect effect given recent recommendations on testing mediation in the absence of a clear direct effect due to concerns with omitting key intervening mechanisms [35, 36]. Indeed, findings showed support for COVID-19 stress being *indirectly* associated with both self and parent-ratings of depression and

self-reported anxiety symptoms through brooding rumination. Further, the effects of COVID-19 stress and brooding rumination did not disproportionately impact internalizing symptoms among adolescents with and without ADHD or among male and female adolescents. Findings highlight the role of brooding rumination as an intervening mechanism that may be one avenue in reducing the prospective risk of COVID-19 on adolescents' mental health symptoms.

Brooding Rumination as a Mechanism Linking COVID-19 Stress to Internalizing Symptoms

Literature to date provides support for elevated internalizing symptoms cross-sectionally and pre-to-post COVID-19 shutdown orders among adolescents [3, 6, 25]. These studies suggest that the many areas of stress related to COVID-19, such as remote learning, family conflict, reduced peer interactions, worry of infection risk, contribute to increased mental health difficulties [7, 10, 11]. Although self-reported COVID-19 stress was significantly correlated with self- and parent-reported internalizing symptoms 1 year later, the direct effect was nonsignificant when controlling for baseline symptoms. Thus, self-reported COVID-19 stress does not appear to directly predict changes in self and parent-reported internalizing symptoms, with the exception of parent-reported depressive symptoms. However, moving beyond solely testing direct links to identifying potential mechanisms that might intervene and explain the link between COVID-19 stress and internalizing symptoms will better inform mechanisms

that are beneficial to target in intervention [1]. Additionally, evaluating indirect effects allows for understanding of developmental processes linking COVID-19 stress to internalizing symptoms over time.

Findings from the current study point to brooding rumination as an intervening mechanism of the prospective association between COVID-19 stress and increased mental health symptoms. Of note, the indirect effect of brooding rumination was significant above and beyond baseline internalizing symptoms, as well as participant characteristics (e.g., medication status, sex). Our findings are consistent with studies documenting brooding rumination as an intervening cognitive mechanism in the relation between environmental stress and mental health symptoms [14, 16–18]. However, and importantly, studies evaluating brooding rumination as an intervening mechanism related to COVID-19 have been conducted cross-sectionally [19–21]. To our knowledge, no study has tested brooding rumination as an intervening mechanism of the prospective association of COVID-19 stress and internalizing outcomes during heightened periods of pandemic stress. Across findings in the current study, there was clear support for COVID-19 stress being indirectly related to self- and parent-ratings of depressive symptoms, in addition to self-reported anxiety symptoms, via brooding rumination. These consistent cross-informant findings for depression align with literature identifying brooding rumination as a cognitive vulnerability for the development and maintenance of adolescents' depressive symptomatology [15, 26]. Adolescents' reporting elevated COVID-19 stress, such as worry of infection risk and frustration with restrictions and closures, coupled with ongoing cognitive perseveration of these feelings and the nature of the COVID-19 situation, are likely to experience increased negative affect and unhelpful thinking, further intensifying internalizing symptoms.

Finally, given previous studies documenting increased COVID-19 related stress and mental health difficulties among adolescents with ADHD [8, 25] and female adolescents [7], we explored ADHD group status and sex as moderators of the indirect effect. Surprisingly, findings showed that the magnitude of the indirect effect did not differ for adolescents with and without ADHD or for female and male adolescents. Although in contrast to what we expected, these findings indicate that COVID-19-related-stress and brooding rumination does not differentially impact anxiety and depressive symptoms among at-risk adolescent populations. However, it is important to acknowledge that correlations showed female adolescents generally had higher self- and parent-reported anxiety and depression symptoms, suggesting that COVID-19 stress and brooding rumination are not exacerbating symptomatology in female adolescents.

Clinical Implications

Our findings suggest that adolescents with tendencies for engaging in excessive brooding rumination are important to identify and target to mitigate the mental health consequences of the COVID-19 pandemic, which might inform prevention efforts for mitigating mental health difficulties in future pandemics or stressful life events. There are a number of recommendations for mental health providers delivering evidence-based services to adolescents. First, cognitive-behavioral techniques aimed at reducing ruminative thinking (e.g., identifying causes and cycles of rumination, mindfulness exercises to get "unstuck," self-compassion, distraction activities at home [37]) may be useful for mitigating the mental health consequences of prolonged stress, particularly during the COVID-19 pandemic. Second, as research has linked poor sleep onset to greater self-reported rumination [38], sleep hygiene and cognitive-behavioral treatments to promote adequate sleep quality during the pandemic (e.g., natural sunlight, exercise [39]) are encouraged. These are important considerations as the pandemic is prolonged, even as it is expected to transition to an endemic classification. These findings also can inform assessment and treatment initiatives in future pandemics or chronic stressors.

Limitations and Future Directions

Despite strengths of the current study, such as the prospective longitudinal design in a sample of adolescents with and without ADHD, a few limitations are important to note. First, our study was likely underpowered to detect moderation effects for adolescent sex and ADHD group status. Future studies are encouraged to evaluate in larger samples. Second, our sample consisted of adolescents identifying as predominately White and from middle to upper class socioeconomic backgrounds. As underserved populations experience particular barriers and stress during COVID-19 restrictions [40], which would likely enhance ruminative processes and mental health symptoms, future research is encouraged to incorporate larger samples of adolescents from racially and economically diverse backgrounds. Along these lines, although participants who agreed to participate in COVID-19 survey ratings (compared to pre-COVID study visits) did not differ on adolescent racial identity, it is possible that these families had the opportunity to dedicate time to survey completion and experienced less COVID-19 disruptions. Further, although beyond the scope of the current study, our measure of COVID-19-related stress was a global rating of stress and negative affect; future research may consider which specific areas of COVID-19 stress or other chronic stress are linked to increased rumination and subsequent

internalizing symptoms. Further, it would be important for studies to test the prospective relations of COVID-19 stress, rumination, and internalizing symptoms beyond the first year of the pandemic, especially as restrictions reduce and adolescents transition to in-person school.

Summary

Findings from this prospective longitudinal study of adolescents with and without ADHD highlight the role of brooding rumination in explaining the association between COVID-19-related stress and increased internalizing symptoms. Future research is encouraged to consider evaluating brooding rumination across different phases of the COVID-19 pandemic, such as transitioning back to fully in-person learning as restrictions loosen, in addition to identifying protective factors of this association (e.g., emotion regulation strategies, peer connection, family support), as well as in other contexts of chronic stress. Brooding rumination may be one intervention target for reducing the negative mental health impact of COVID-19 in adolescents; this is a critical area for future research.

Declarations

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