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The relationship between stress responding in family context and stress sensitivity with sleep dysfunction in individuals at clinical high-risk for psychosis

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ABSTRACT

Stress and sleep have been implicated in the etiology of psychosis, and literature suggests they are closely related. Two distinct domains of stress associated with sleep dysfunction in the general population are responsivity to environmental stressors and stress sensitivity. However, to date, no research has examined relationships between these stress domains and sleep dysfunction in individuals at clinical high-risk (CHR) for psychosis. A total of 57 CHR (mean age = 18.89, SD = 1.82) and 61 healthy control (HC; mean age = 18.34, SD = 2.41) adolescents and young adults completed a measure of emerging stress intolerance. A subset of participants (CHR = 50, HC = 49) completed a measure indexing responsivity to family stressors - an integral context for this developmental stage overlapping with the psychosis-risk period. Sleep efficiency, continuity, and duration were objectively assessed by actigraphy (CHR = 38, HC = 36). Partial correlations with age and sex as covariates were conducted in both groups separately to examine relationships between stress and sleep. Results indicated that automatic maladaptive responsivity to family stressors was associated with disrupted sleep in the CHR but not HC group. Specifically, greater involuntary engagement was associated with poorer sleep efficiency (r = −.42) but not sleep continuity (r = 0.31) and duration (r = .-19). Interestingly, both adaptative and maladaptive voluntary responses to stressors (engagement and disengagement coping) were not associated with sleep. Finally, impaired stress tolerance was associated with sleep efficiency (r = −0.47), continuity (r = 0.37), and duration (r = −0.43). Taken together, findings provided important groundwork for understanding the role of the relationship between involuntary maladaptive responsivity to family stressors and stress sensitivity with sleep in psychosis etiology.

1. Introduction

Environmental and biological stressors have been implicated as prominent factors in the etiology of psychotic disorders (Pruessner et al., 2017; Trotman et al., 2014; Walker et al., 2008). Impact of stress is evident prior to illness onset in individuals at clinical high-risk (CHR) for psychosis. This population presents with attenuated symptoms and declines in social and role functioning (Fusar-Poli et al., 2012). One critical aspect observed in individuals at CHR for psychosis is maladaptive responsivity to environmental stressors (Jalbrzikowski et al., 2014; Phillips et al., 2012). Familial conflict is particularly important to consider in the context of emerging psychosis symptoms given the role of family during this critical developmental period (O'Brien et al., 2006; Robustelli et al., 2017). Another important domain of stress is an emerging difficulty with tolerance to normal stress (Devylder et al., 2013; Trotman et al., 2014). This stress sensitivity likely reflects changes in biological stress systems (Dean et al., 2016; McEwen, 2015; Myin-Germeys and van Os, 2007). A separate, but related, line of research implicates sleep abnormalities in psychosis development (Clarke et al., 2021; Lunsford-Avery et al., 2013; Zanini et al., 2013). Objective measures of sleep such as actigraphy indicate elevated sleep disturbances in psychosis-risk populations (Hennig et al., 2020; Lunsford-Avery et al.,

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2015). The links between stress and sleep dysfunction are evident in the general population (Chiang et al., 2016; van Dalfsen and Markus, 2018), and evidence from schizophrenia literature suggests poor sleep is related to maladaptive coping mechanisms (Hofstetter et al., 2005). However, broad links between stress and sleep dysfunction have not yet been studied in the psychosis-risk populations. More specifically, examining the relationship between maladaptive stress responsivity and emerging sensitivity to stressors with objective measures of sleep in individuals at CHR for psychosis could yield important insights into psychosis pathogenesis.

Individuals at CHR for psychosis endorse elevated exposure to psychosocial stressors such as daily hassles, relational problems, and major life events (Cullen et al., 2020; Ristanovic et al., 2020; Tessner et al., 2011). Responsivity to such stressors is particularly important to consider in the context of family dynamics. Indeed, among youth at CHR for psychosis, a more critical family environment predicts worsening of symptoms over time (Schlosser et al., 2010) while a positive family environment is associated with improved outcomes (O'Brien et al., 2006; Schlosser et al., 2010). Moreover, adolescents at CHR for psychosis present with more challenging family environments (Salinger et al., 2018). These challenges coupled with maladaptive stress responsivity highlight the importance of investigating strategies for responding to family conflict. Our group has demonstrated that in the context of interactions with parents, individuals at CHR for psychosis employ more maladaptive coping strategies (i.e., disengagement coping such as avoidance and denial) when compared to healthy controls (HCs; Yee et al., 2020). Additionally, in other contexts, this population less frequently engages in adaptive coping such as problem solving and more in maladaptive ones (Jalbrzikowski et al., 2014; Phillips et al., 2012). However, automatic maladaptive responses to stressors such as involuntary engagement (e.g., rumination and emotional arousal) which signify physiological stress reactivity (Brewer and Santiago, 2018), have not yet been examined in psychosis-risk populations.

In addition to maladaptive stress responding, youth at CHR for psychosis present with emerging difficulties with tolerance to normal stress (Dean et al., 2016; Pruessner et al., 2011; van der Steen et al., 2017). More impaired tolerance is associated with worse positive and negative symptoms of psychosis (Devylder et al., 2013; Munoz-Samons et al., 2021), global functioning declines (Munoz-Samons et al., 2021), and worsening of positive symptoms over time (Devylder et al., 2013; Ristanovic et al., 2020). As noted, impaired tolerance to stress likely reflects an index of changes in biological and psychological stress systems (McEwen, 2015; Myin-Germeys and van Os, 2007; Pruessner et al., 2011) and is mechanistically involved in pathogenesis of psychosis via alterations in the hypothalamic-pituitary-adrenal (HPA) axis (Corcoran et al., 2012; Devylder et al., 2013; Trotman et al., 2014) and in the hippocampus (Dean et al., 2016). This is consistent with the diathesis-stress model which posits that a constitutional vulnerability to psychosis interacts with environmental stress to ultimately drive illness onset (Pruessner et al., 2017; Walker et al., 2008).

Further, emerging research suggests sleep disturbances are prevalent during the psychosis-risk period (Clarke et al., 2021; Hennig et al., 2020; Lunsford-Avery et al., 2013, 2015; Poe et al., 2017). Subjective and self-report measures of sleep indicate that individuals at CHR for psychosis present with reduced sleep quality as indicated by lower perceived quality, greater time required to fall asleep, shorter sleep duration, lower sleep efficiency, and related greater daytime dysfunction (Lunsford-Avery et al., 2013; Zanini et al., 2013). Furthermore, studies utilizing objective measures of sleep such as actigraphy, polysomnography, and electroencephalogram demonstrate significant sleep disturbances are present prior to psychosis onset (Clarke et al., 2021; Mayeli et al., 2021; Zanini et al., 2015). Our group employed a study using actigraphy and found that sleep efficiency and wake time after onset (WASO; sleep continuity) but not total sleep time (TST; sleep duration) are disrupted in individuals at CHR for psychosis (Lunsford-Avery et al., 2015). Importantly, sleep disturbances are related to elevated attenuated psychosis symptoms and poorer functioning both cross-sectionally and over time (Clarke et al., 2021; Lunsford-Avery et al., 2013). Clinician-rated sleep problems are associated with positive and negative symptoms and general functioning (Poe et al., 2017). Moreover, actigraphy measures of sleep are predictive of symptom worsening over a 12-month period (Lunsford-Avery et al., 2015, 2017). Taken together, these findings implicate sleep as an important factor affected during the pathogenesis of psychosis.

Importantly, the relationship between stress and sleep has not been investigated in youth at CHR for psychosis. In the general population, stress-related psychopathology and biological markers of stress are tightly related to sleep disturbances (Chiang et al., 2016; van Dalfsen and Markus, 2018). Two dimensions of sleep particularly relevant to examine in the context of stress-related psychiatric disorders among youth are sleep efficiency/continuity and sleep duration. In fact, reduced sleep efficiency may potentiate the sensitivity of the HPA-axis in response to psychosocial stressors (van Dalfsen and Markus, 2018). Additionally, markers of altered HPA axis reactivity to stress is tied to reduced sleep duration (D'Aurea et al., 2015; Minkel et al., 2014). And in typically developing adolescents, during times of higher stress, sleep duration and efficiency are reduced (Astill et al., 2013). Furthermore, these indicators of sleep have also been associated with family stress. Specifically, more negative effects of family stress on emotional adjustment and biological stress responses among youth are associated with lower sleep efficiency (Chiang et al., 2016, 2017). Additionally, stressful family environment is associated with lower sleep duration (Schmeer et al., 2019; Tsai et al., 2018). Investigating the relationship between stress and sleep in psychosis risk is poised to provide novel insights into psychosis etiology.

The purpose of the current study was to understand the critical relationship between stress and sleep prior to psychosis onset. We sought to examine associations between two distinct measures of stress and sleep actigraphy. First, our previous work suggests that in the context of family stress, voluntary maladaptive but not adaptive coping patterns are elevated in the CHR group when compared to controls (Yee et al., 2020). Furthermore, there is evidence to demonstrate that youth in stressful family environments exhibit disrupted sleep (Chiang et al., 2016, 2017; Schmeer et al., 2019; Tsai et al., 2018). Based on these findings, it was predicted that greater employment of maladaptive stress responding (involuntary engagement responding and disengagement coping) but not adaptive engagement coping will be associated with lower sleep efficiency, greater wake after sleep onset (WASO; i.e., sleep continuity), and lower total sleep time (TST; i.e., sleep duration). Additionally, in line with evidence form the general population on the links between biological stress and sleep (D'Aurea et al., 2015; Minkel et al., 2014), it was predicted that greater impaired tolerance to stress will be associated with lower sleep efficiency, greater WASO, and lower TST. Lastly, based on previous work suggesting associations between sleep and symptoms (Lunsford-Avery et al., 2015; Poe et al., 2017), the current study aimed to examine potential mediating effects of attenuated positive symptoms on the stress-sleep relationship.

2. Material and methods

All procedures have been conducted in accordance with the Declaration of Helsinki updated in 2013. The study protocol has been reviewed and approved by the Institutional Review Board. Participants and legal guardians signed informed consent/assent forms after the procedures had been fully explained.

2.1. Participants

Participants were recruited at the Adolescent Development and Preventive Treatment Program. The sample included 57 CHR (23 female, 34 male, mean age 18.89, SD = 1.82) and 61 HC (33 female, 28 male, mean age 18.34, SD = 2.41) participants (See Table 1). Consistent

Table 1
Demographic, stress, and sleep characteristics by group.

	CHR	HC	*p*
Sex			
Males	23	33	
Females	34	28	
Total	57	61	NS
Age			
Mean years (SD), range	18.89 (1.82), 13-22	18.34 (2.41), 12-21	NS
Race – n (%)			NS
First Nations	3 (5.3)	–	
East Asian	2 (3.5)	5 (8.2)	
Southeast Asian	–	1 (1.6)	
Black	1 (1.8)	2 (3.3)	
Central/South American	10 (17.5)	17 (27.9)	
White	39 (68.4)	35 (57.4)	
West/Central Asian	1 (1.8)	1 (1.6)	
More than one race	1 (1.8)	–	
Ethnicity – n (%)			
Hispanic	13 (19.7)	19 (26.4)	NS
Parental education			
Mean years (SD), range	15.40 (2.88), 7-20	15.11 (3.65), 4-20	NS
Involuntary Engagement			
Mean (SD), range	.82 (.47), 0–1.73	.44 (.53), 0–2.47	.001
Engagement Coping			
Mean (SD), range	1.15 (.52), 0–2.39	1.03 (.71), 0–2.56	NS
Disengagement Coping			
Mean (SD), range	.94 (.54), 0–2.33	.58 (.53), 0–1.78	.001
Impaired Stress Tolerance			
Mean (SD), range	.83 (.63), 0–1.95	.06 (1.91), 0-.69	<.001
Sleep Efficiency			
Mean (SD), range	84.7 (8.79), 47.4–97.5	88.1 (4.61), 79.3–96.9	.03
WASO			
Mean (SD), range	71.3 (51.35), 12–304.3	54.21 (23.68), 13–101.8	.05
TST			
Mean y(SD), range	394.1 (69.04), 285.3–542.5	411.1 (71.64), 301.3–587	NS

Note: NS = not significant; CHR = clinical high-risk; HC = healthy controls; sleep efficiency = percent of sleep epochs; WASO = wake time after onset in minutes; TST = total sleep time in minutes.

with our previous relevant work (Lunsford-Avery et al., 2015; Yee et al., 2020), CHR participants met criteria for the psychosis-risk syndrome by one or more of the following: 1) presence of attenuated psychosis symptoms, 2) presence of schizotypal personality disorder with global functioning decline or age <19, and 3) a family history of psychosis with global functioning decline. Exclusion criteria for all participants included age <12 or >24, psychotic disorder diagnosis, history of head injuries and neurological disorders, and a lifetime diagnosis of substance use. Additional exclusionary criteria for HC participants included meeting criteria for any psychosis-risk syndrome, any Axis I diagnoses, and family history of psychosis.

2.2. Clinical measures

Psychodiagnostic interviews were administered by assessors trained to reliability standards ($\alpha > 0.80$). The Structured Clinical Interview for Psychosis Risk Syndromes (SIPS; McGlashan et al., 2010; Miller et al., 1999) was used to diagnose psychosis-risk syndromes in CHR participants and rule out symptoms in HCs. The Structured Clinical Interview for DSM-IV (SCID; First et al., 2012) was administered to rule out psychosis and assess for other psychiatric disorders in both groups.

2.3. Responsivity to family stress

A 42-item version of the Response to Stress Questionnaire (RSQ) was used to assess coping in response to stress related to interactions with parents (Connor-Smith et al., 2000). Participants were asked to rate the extent to which they used different coping strategies when responding to stressful interactions with fathers and then with mothers in the last 4 months on a 4-point scale from 0 ("not at all") to 3 ("a lot"). RSQ measures three domains of responsivity to stressors. Based on the factor structure reported by Connor-Smith et al. (2000), engagement coping strategies (alpha: 0.87 [fathers] and 0.84 [mothers]) include problem solving, emotion regulation, positive thinking, cognitive restructuring, acceptance, and distraction; disengagement coping strategies (alpha: 0.81 [fathers] and 0.83 [mothers]) include avoidance, denial, and wishful thinking; and involuntary engagement response (alpha: 0.85 [fathers] and 0.82 [mothers]) include rumination, intrusive thoughts, physiological arousal, emotional arousal, and involuntary action. Each of these domains is measured by three questions. The composite domain scores were used in analyses, and higher scores indicate more use of strategies in each category. Responses to mother and father versions were highly correlated on item and domain levels, so the mean value was used in all analyses. RSQ data was available for 50 CHR and 49 HC participants.

2.4. Stress sensitivity

Trained clinical assessors used the SIPS to assess and rate impaired tolerance to normal stress rated on a 7-point Scale of Prodromal Symptoms (SOPS) from 0 ("absent") to 6 ("extreme"). This item measures increasing challenges and inability to cope with daily activities and stressful situations. It is identified as a "general symptom" and based on the principal component analysis of the SOPS assessments, it does not load on positive or negative symptom factors (Hawkins et al., 2004). This scale has been previously used to assess changes in stress tolerance in psychosis-risk populations (Devylder et al., 2013; Sugranyes et al., 2012).

2.5. Sleep actigraphy

ActiSleep monitors (ActiGraph; Pensacola, FL) were used to objectively measure sleep efficiency (percent of sleep epochs between sleep start and sleep end), sleep continuity: wake after sleep onset (WASO, number of minutes awake between sleep start and sleep end), and sleep duration: total sleep time (TST; minutes from sleep start to sleep end). Participants wore it for 5 consecutive days on their non-dominant wrist, and epoch lengths were recorded in 60-s intervals. Additionally, participants recorded lights-out time, wake time, school attendance, naps, physical illness, and participation in activities in a daily sleep/activity diary (Ancoli-Israel et al., 2003). Automatic scoring of target variables was completed in the ActiLife program (version 5.10.0) using the developmentally appropriate Sadeh algorithms (Sadeh, 2011). Data were also hand-checked for accuracy, and the sleep/activity diary was used to confirm sleep onset and offset times. Inclusion threshold for analyses was at least 3 out 5 accurate actigraph readings; 2 CHR and 0 HC participants were excluded because of insufficient data. Actigraphy data was available for 38 CHR and 36 HC participants.

2.6. Statistical approach

Shapiro-Wilk tests were used to examine normality of the data. Due to the evidence of non-normality, impaired tolerance to stress variable was log-transformed. Independent samples t-tests and chi-square tests were used to test differences in continuous and categorical demographic variables, respectively. Univariate analyses of covariance (ANCOVAs) were used to evaluate group differences on coping strategies, impaired tolerance to stress, and actigraphy variables. Partial correlations, were used to examine associations between sleep and stress responsivity variables in the CHR group. Multiple linear regressions with bootstrapping were used to determine the potential mediating effect of attenuated positive symptoms between stress and sleep. Based on prior

findings indicating the impact of sex and age on circadian rhythms in adolescence, these variables were included as covariates (Mateo et al., 2012; Robillard et al., 2013).

3. Results

3.1. Participant characteristics

The groups did not differ on any demographic variables including age ($t(116) = 1.39, p = .12$), sex ($\chi^2(1, N = 118) = 2.23, p = .13$), race ($t(116) = 0.80, p = .42$), ethnicity ($\chi^2(1, N = 118) = 1.20, p = .27$), and parental education ($t(116) = 0.30, p = .77$). Participants with and without actigraphy data were also matched on demographic variables (See Supplementary Document). For group differences in stress and sleep measures, see supplementary document and Fig. 1.

3.2. Associations between stress responsivity and sensitivity with sleep disturbances

First, involuntary engagement in response to family stress and impaired tolerance to normal stress were moderately correlated (r = .34, p = .001). This association indicated moderate criterion validity of the measures but also highlighted each may be picking up on the unique variance related to the stress system. Next, partial correlations revealed that in the CHR group, increased involuntary engagement was associated with poorer sleep efficiency, r = −.42, p = .04 (Fig. 2), but not wakefulness after sleep onset, WASO (r = 0.31, p = .14) or total sleep time, TST (r = −0.19, p = .35). Disengagement coping was not significantly associated with any actigraphy variables (sleep efficiency, r = −0.21, p = .21; WASO, r = 0.25, p = .19; or TST r = −0.11, p = .56). There were no significant correlations between engagement coping and actigraphy (sleep efficiency, r = −0.25, p = .31; WASO, r = 0.34, p = .16; or TST r = −0.11, p = .66). Lastly, more impaired stress tolerance was significantly associated with all actigraphy measures (sleep efficiency, r = −0.47, p = .004; WASO, r = 0.37, p = .03; and TST r = −0.43, p = .009) (See Table 2). In the HC group, there were no significant correlations between stress and sleep measures (see supplementary document).

3.3. Mediating effects of attenuated positive symptoms between stress and sleep in the CHR group

Involuntary engagement, disengagement, and engagement coping were not associated with attenuated positive symptoms. Therefore, mediation analyses were not conducted for these variables. Impaired tolerance to stress was a significant predictor of all actigraphy variables. Regression analyses indicated attenuated positive symptoms fully mediated the relationship between impaired tolerance to stress and WASO (ACME = .002, p = .04) and no mediation effects on sleep efficiency (ACME = −0.007, p = .1) and TST (ACME = −0.0002, p = .9).

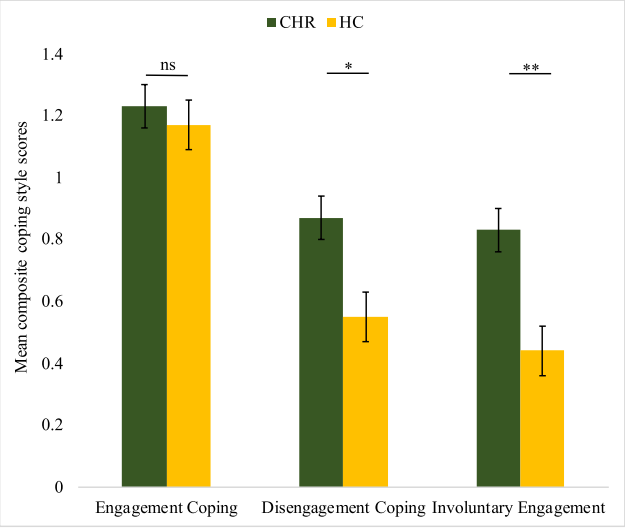

Fig. 1. Group differences in responding to family stressNotes:*p = .001, **p < .0001; CHR = clinical high-risk; HC = healthy controls.

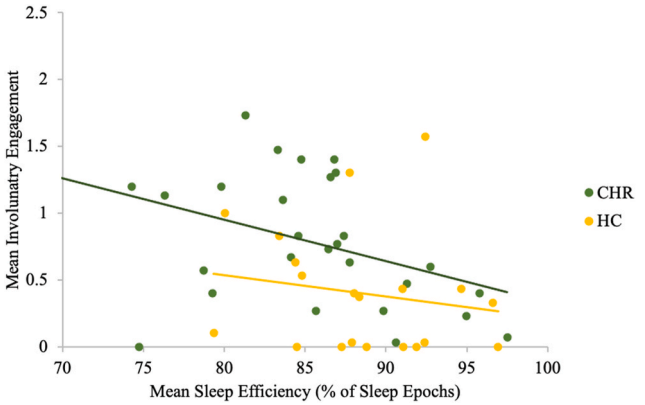

Fig. 2. Association between involuntary engagement and sleep efficiency.

Table 2
Partial correlations between actigraphy and stress variables.

	CHR			HC		
	Efficiency	WASO	TST	Efficiency	WASO	TST
Engagement Coping	-.25	.34	-.11	-.12	.19	.31
Disengagement Coping	-.21	.25	-.11	-.12	.13	-.2
Involuntary Engagement	-.42*	.31	-.19	-.21	.18	-.18
Stress Intolerance	-.47**	.37*	-.43**	-.21	.21	-.03

Note: *p < .05, **p < .01; CHR = clinical high-risk; HC = healthy controls; WASO = wake after sleep onset; TST = total sleep time; age and sex are covariates for all correlations.

4. Discussion

The current study was the first to examine the relationship between stress indices and sleep dysfunction in individuals at risk for psychosis. The focus of the study was on two distinct domains of stress: stress responsivity, or the voluntary and involuntary ways in which a person responds to environmental stressors, and stress sensitivity, or the disrupted ability to tolerate normal stressors. First, the findings provided novel insights into elevations in automatic stress responding (i.e., involuntary engagement) in this group. Next, the results confirmed the previous findings of increased use of disengagement coping strategies (Yee et al., 2020) and elevated stress intolerance (Ristanovic et al., 2020). Further, consistent with previous findings from our group (Lunsford-Avery et al., 2015), individuals at CHR for psychosis presented with disrupted sleep efficiency and continuity but not duration when compared to HCs. Critically, correlational analyses indicated a relationship between stress and sleep in the CHR group. Specifically, higher involuntary engagement was associated with poorer sleep efficiency, and more impaired tolerance to stress with sleep dysfunction in both domains. Interestingly, both voluntary coping strategy types were not related to any sleep domain. These findings highlight a potential pathogenic role of the dynamic link between automatic stress responding and sensitivity with sleep in the etiology of psychosis.

In the context of responding to stressful parental interactions, the results indicated that youth at CHR for psychosis engaged in

maladaptive strategies to a greater extent than HCs. Specifically, they endorsed significant involuntary engagement responses (e.g., emotional arousal) to stressful interaction with parents. These automatic physiological responses to familial stress provide further evidence for dysregulation of the stress reactivity system (Brewer and Santiago, 2018). In fact, involuntary stress responses are related to indicators of increased activity of the HPA axis (Zoccola and Dickerson, 2012). Further, the results confirmed that individuals at CHR for psychosis engage in more maladaptive coping strategies (e.g., avoidance). On the contrary, they engage in adaptive coping (e.g., problem solving) at similar rates as HCs. Taken together, these findings are consistent with the literature indicating that involuntary stress responses may contribute to ineffective coping in youth (Bendezu et al., 2016). These maladaptive patterns of stress responsivity in the context of family dynamics are particularly concerning in psychosis-risk populations. It is possible that decreases in peer contact among individuals at CHR for psychosis are contributing to higher reliance on parents for social support (Robustelli et al., 2017). Indeed, this population presents with declines in social functioning and increases in social isolation (Robustelli et al., 2017; Velthorst et al., 2018) as well as emerging asociality (Piskulic et al., 2012). These results coupled with evidence of difficult family environments for youth at CHR for psychosis (Salinger et al., 2018; Schlosser et al., 2010) indicate the need for interventions targeting family dynamic to improve clinical outcomes.

As expected and consistent with previous findings (Dean et al., 2016; Devylder et al., 2013; Munoz-Samons et al., 2021; Ristanovic et al., 2020), the current study indicated more impaired stress tolerance in the CHR group compared to HCs providing additional evidence for vulnerability of the stress system prior to illness onset. These changes in the experience of daily stressors may be indicative of dysregulation of the biological stress systems including alterations in HPA-axis activity (Corcoran et al., 2012; Trotman et al., 2014). In fact, the biological markers of HPA-axis overactivation, such as elevated cortisol secretion, are related to subjective measures of intolerance to stress (Sugranyes et al., 2012). The damage to these systems could also be interacting with coping and resiliency capabilities and clinical outcomes. For example, in individuals with schizophrenia, effective use of coping strategies is associated with improved quality of life only in those individuals with more blunted cortisol response (Brenner et al., 2011). And in youth at CHR for psychosis, adaptive coping is associated with improvements in positive and negative symptoms over time and vice versa (Jalbrzikowski et al., 2014). Considering the emerging intolerance to normal daily stress in this population, further examining styles of responding to environmental stressors is critical.

In addition to emerging stress sensitivity and maladaptive responsiveness to family stressors, the current study confirmed the findings of disrupted sleep prior to psychosis onset. Consistent with our previous findings, the CHR group presented with more time awake between sleep onset and end and less efficient sleep but comparable total time asleep to HCs (Lunsford-Avery et al., 2015). While evidence for sleep disturbances in schizophrenia is largely consistent (Chan et al., 2017; Meyer et al., 2020; Reeve et al., 2015), a recent meta-analysis indicated that in the psychosis-risk literature, findings related to sleep efficiency/continuity and duration are somewhat mixed (Clarke et al., 2021). It is possible that potential confounding variables such as exposure to stress are differentially potentiating sleep disturbances via alterations in the HPA function (Nollet et al., 2020). Nevertheless, considering that both efficiency/continuity and duration sleep domains are predictive of positive symptoms worsening over time (Lunsford-Avery et al., 2015), they appear particularly relevant prior to illness onset.

Importantly, the current study provided preliminary insights into the relationship between stress responsivity and sensitivity and sleep in individuals at CHR for psychosis but not in HCs. The correlational analyses indicated that involuntary responsivity to stressors in the family context and stress sensitivity but not voluntary coping strategies (engagement and disengagement coping) are associated with poorer sleep. Specifically, increased involuntary engagement was associated with poorer sleep efficiency. Those with more impaired tolerance to stress exhibit less total time asleep, more time awake between sleep onset and end, and less efficient sleep. These findings are consistent with the diathesis-stress model of psychosis. First, there is evidence to suggest a genetic liability related to sleep in psychosis (Lunsford-Avery and Mittal, 2013). Second, impairment of the stress systems evident in the youth at CHR for psychosis may be further impacting sleep. Indeed, exposure to stress can contribute to sleep disturbances which conversely may lead to proliferation of the HPA-axis reactivity via increases in circulating levels of cortisol (Hori et al., 2011; Nollet et al., 2020). However, the directionality of the effect is not clear. Notably, human and animal models suggest that the relationship between stress and sleep relative to the HPA function can be reciprocal (Nollet et al., 2020; Raikkonen et al., 2010). Nevertheless, sustained impact from both overactivation of the HPA-axis and chronically disrupted sleep can further damage the already vulnerable system. This process in turn can contribute to increased inability of the system to disengage from maladaptive stress responsivity and tolerate stress, thereby contributing to more dysfunctional sleep and further conferring risk for psychosis (Hori et al., 2011; Lunsford-Avery and Mittal, 2013; Nollet et al., 2020). Lastly, attenuated positive symptoms did not mediate the relationship between stress and sleep suggesting a different mechanism by which maladaptive coping and stress intolerance contribute to disrupted sleep.

The current study presents with some limitations. First, while clinician ratings of emerging intolerance to stress can inform changes in biological vulnerability, future studies would benefit from examining discrete biological indicators of stress sensitivity and their associations with sleep. Next, although the actigraphy variables are an objective measure of sleep characteristics, this method does not measure sleep physiology. Future studies should incorporate methodology capturing physiological parameters to further assess sleep health in this group. Further, the correlational analyses did not correct for multiple comparisons or account for the directionality of effects. A recent review emphasized an intricate and reciprocal relationship between stress and sleep relative to HPA function (Nollet et al., 2020). To that end, future studies should examine directionality as more nuanced findings could inform mechanisms linking stress and sleep during psychosis pathogenesis. Next, the sample size was small, particularly for actigraphy and RSQ analyses. More powered studies would benefit from examining whether stress and sleep disturbances interact to predict symptomatology. Additionally, the available data did not allow for examining the temporal relationship between stress and sleep measures. Lastly, given the racial composition of the sample, the results may not be generalizable to racial minority populations. The current study provided preliminary findings indicating the association between maladaptive responsivity to family stressors and impaired tolerance to stress with disrupted sleep prior to psychosis onset. Taken together, the results emphasize the need for developing targeted interventions aimed to improve coping skills including family interventions. Family focused therapy for individuals at CHR for psychosis has been found to improve positive symptoms and functioning (Miklowitz et al., 2014). Similar interventions could mitigate the impact of stress on sleep function, thereby improving clinical outcomes.

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Declaration of competing interest

The authors declare no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2022.02.038.

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