

1 Childhood trauma and stressful life events are 2 independently associated with sleep disturbances in 3 adolescents

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18 **Abstract:** Adolescence is a critical developmental period associated with an increase in stress, the
19 appearance of anxiety and depressive symptoms, and changes in sleep patterns. Even though the
20 disruption of sleep patterns in stress and anxiety and depressive disorders is well known, the
21 independent effects of childhood trauma and stressful life events on sleep patterns are less
22 understood. We tested the independent effects of stress (childhood trauma and stressful life events)
23 while controlling for anxiety and depression on adolescent sleep patterns. Seven hundred fifty-two
24 adolescents completed self-report questionnaires about childhood trauma, stressful life events,
25 anxiety, and depression. Four sleep factors identifying movement during sleep, sleep regularity,
26 sleep disturbances and sleep pressure were extracted in the principal component analysis of sleep
27 questions. Both childhood trauma and recent stressful life events were significantly associated with
28 sleep disturbances before and after controlling for anxiety and depression.

29 **Keywords:** childhood trauma; stressful life events; sleep patterns; anxiety; depression, adolescence
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32 1. Introduction

33 Adolescence is a critical transitional period associated with an increase in stress, significant
34 social readjustments [1] and high reactivity to stress [2]. Stress in the form of childhood trauma is
35 common [3] and associated with the development of mental health disorders [4–6], lower school
36 engagement [7] and poor health outcomes [6]. Childhood trauma is also associated with a high
37 suicide rate [5]. Stress in the form of stressful life events is also common in childhood and adolescence,
38 and impact psychological functioning [8,9], mental health symptoms and substance use [10]. Severe
39 stressful events in childhood are associated with anxiety and depression in adolescents [11–14].
40 Interestingly, in a study that assessed both childhood trauma and stressful life events, childhood
41 trauma but not stressful life events were associated with developing anxiety and depressive
42 symptoms [15,16].

43 Childhood trauma such as sexual abuse and physical abuse are associated with multiple sleep
44 disturbances such as difficulty falling asleep, staying asleep and increased activity during sleep
45 [17,18]. Similarly, stressful life events are associated with sleep disturbances such as insomnia [19,20].

46 Higher the number of adverse childhood experiences, higher the sleep disturbances suggesting a
47 graded relationship between stressful life events and sleep [21,22].

48 Both childhood trauma and stressful life events are associated with the development of mental
49 health disorders in adolescence. Adolescent mental health disorders are common, with 31.9% of
50 adolescents reporting an anxiety disorder and 14% a mood disorder in a national survey of mental
51 health symptoms [23]. Anxiety and depression consistently present with sleep problems that include
52 obtaining less sleep, trouble falling asleep [24,25] and irregular sleep patterns [26]. The directionality
53 of sleep and mental health symptoms is unclear as sleep disturbances are known to precede [27–29]
54 or accompany the appearance of anxiety and depressive symptoms. Although the subjective reports
55 of sleep disturbances are well known, the associated objective correlates of sleep problems are less
56 understood [18]. Dysregulated Hypothalamus – Pituitary – Adrenal (HPA) axis and the altered
57 feedback mechanisms have been identified in anxiety [30], depressive symptoms [26], stressful events
58 [32] and disruption of sleep patterns [33]. However, the exact pathophysiology underlying the
59 comorbid presentation of sleep disturbances in anxiety, depression and stress manifestations are less
60 well understood.

61 Even though the disruption of sleep patterns in childhood trauma and anxiety and depressive
62 symptoms is known, the independent contribution of childhood trauma and stressful life events on
63 childhood on sleep patterns has not been investigated. Herein, we explored the effects of childhood
64 trauma and stressful events in the past year on sleep patterns after controlling for anxiety and
65 depression. One such study in adults identified that at least one disrupting stressful life event in the
66 past four months was associated with sleep disturbances in depressed adults but not controls [34].
67 Building upon the current literature of the effects of childhood stress on sleep and anxiety and
68 depressive symptoms, we investigated if childhood trauma and stressful life events are
69 independently associated with altered sleep patterns in adolescence.

70 2. Materials and Methods

71 2.1 Participants and Procedures

72 Seven hundred fifty-two adolescents between the ages of 12 years and 14 years 11 months
73 were recruited from the greater San Antonio area for a longitudinal study to evaluate the
74 development of alcohol use disorders and depressive disorders. Initial screening excluded
75 those with a diagnosis of Autism Spectrum Disorder and those with an IQ less than 80
76 based on prior testing or estimated. Subjects with floating metallic objects and dental braces
77 were excluded because of the MRI component of the study. The adolescent participant and
78 their guardian were invited to come for an on-site visit to fill out questionnaires assessing
79 sleep patterns, childhood trauma, stressful life events and anxiety and depressive
80 symptoms. We are presenting the analyses from the baseline questionnaires. The study was
81 approved by the Institutional Review Board at University of Texas Health Science Center
82 at San Antonio (Institutional Review Board registered codes IRB00000553, IRB00002691,
83 IRB00002692 and IRB00009608).

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86 2.2 Measures

87 Sleep patterns: Sleep patterns were extracted from eleven sleep questions in the Dimensions of
88 Temperament Survey (DOTS) and four questions in the Youth Self Report (YSR). Dimensions of
89 Temperament Survey is a widely used instrument developed to measure temperament [35] and the
90 Youth Self Report is a questionnaire commonly used for assessing emotional and behavioral
91 disorders [36]. Sleep questions extracted from the Dimensions of Temperament Survey [35] evaluated
92 the regularity of bedtime, wake time, moving in sleep, moving in bed, and naps—each rated “Usually
93 false” scored “1”, “More false than true” scored “2”, “More true than false” scored “3” and “Usually
94 true” scored “4”. Sleep questions in the Youth Self Report assessed if the adolescents obtained less

95 sleep, had trouble sleeping, needed more sleep and experienced nightmares—rated “not true” scored
96 “0”, “Sometimes or Somewhat true” scored “1” and “very true” scored “2” (Table 2). Sleep questions
97 from the Youth Self Report and Dimensions of Temperament Survey were used in prior studies for
98 assessing sleep patterns [37–40].

99 Childhood trauma: Childhood trauma was assessed by the Childhood Trauma Questionnaire
100 (CTQ). The CTQ is a 28-item validated instrument to measure physical, sexual and emotional trauma
101 in childhood [41–43]. CTQ has a high internal consistency ($\alpha = 0.95$; 0.63 – 0.95) and test-retest
102 reliability (Intraclass Correlation Coefficient = 0.88) [43]. The questions assessed components of
103 childhood stress such as physical abuse (i.e., I believe that I was physically abused), sexual abuse (i.e.
104 Someone molested me), emotional abuse (i.e., People in my family said hurtful or insulting things to
105 me), emotional neglect (i.e., I didn’t have enough to eat) and physical neglect. Each question was
106 rated “never true” scored “1”, “rarely true” scored “2”, “sometimes true” scored “3”, “often true”
107 scored “4”, and “very often true” scored “5”. The scores for each of the subscales ranged from 5-25
108 and were summed to obtain the total score. The cutoff scores for various subscales of abuse were the
109 following: physical abuse, 10 or higher; sexual abuse, 8 or higher; emotional abuse, 13 or higher;
110 emotional neglect, 15 or higher; physical neglect, 10 or higher [42].

111 Stressful Life Events: Stressful life events in the past year were assessed by the Stressful Life
112 Events Schedule (SLES). SLES is an 80-item stress measure validated to measure objective and
113 subjective stress from life events experienced by adolescents in the past 12 months with a test-retest
114 reliability $k = 0.68$ (95% CI, 0.64–0.72) and inter-rater reliability for objective threat ($k = 0.67$ ranged
115 from 0.58 to 0.89). The stress questions assessed life events at school (i.e., I changed schools), job (i.e.,
116 I had problems at my job), family (i.e., My family had money problems), legal (i.e., I was a victim of
117 a crime) and personal events (i.e., I had relationship problems with my boyfriend/girlfriend). Each
118 question was rated “not at all” scored “0”, “a little” scored “1”, “somewhat” scored “2” and “lot”
119 scored “3”. Subjective stress score was obtained from the self-report score, whereas the objective
120 stress score was calculated from the objective threat scores given by neutral raters [44].

121 Anxiety symptoms: Anxiety symptoms were assessed by Screen for Child Anxiety Related
122 Emotional Disorders (SCARED). The SCARED self-report questionnaire is a 41-item instrument for
123 measuring anxiety symptoms in children and adolescents and has high internal consistency ($\alpha = 0.93$;
124 0.70 to 0.90) and test-retest reliability (intraclass correlation coefficients = 0.86 0.70 0.90). The scale
125 assesses DSM IV based symptoms of Generalized Anxiety Disorder, Separation Anxiety Disorder,
126 Panic Disorder, Social Phobia and School Phobia and calculates a total anxiety score for the past three
127 months [7]. Each question was rated on a 3-point scale: “almost never” scored “0”, “sometimes”
128 scored “1” and “often” scored “2”. A total score was calculated from summing individual questions.
129 The scores of the SCARED questionnaire have a range from 0-69. A total score of ≥ 25 in clinical
130 samples is suggestive of an anxiety disorder [46].

131 Depressive symptoms: Depressive symptoms were assessed by the Mood and Feelings
132 Questionnaire Child version (MFQ-C) [38]. The Mood and Feelings Questionnaire is a 34-item
133 instrument that measures depressive symptoms in the prior two weeks in the age group 8-18 years
134 and has a high internal consistency ($\alpha = 0.90$) and test-retest reliability (intraclass correlation
135 coefficient = 0.75). The questions assess depressive symptoms based on DSM III criteria on a three-
136 point scale: “not true” scored “0”, “sometimes true” scored “1” and “true” scored “2”. The depressive
137 symptoms score was calculated after removing the two sleep questions from the Mood and Feelings
138 Questionnaire. The score of the Mood and Feelings questionnaire has a range from 0 – 64. The cutoff
139 scores for MFQ used in previous studies is as follows: MFQ < 20 as low, MFQ 20-34 as medium and
140 MFQ >34 as high for depression. Wood et al identified a cutoff score of 27 that represented Major
141 Depression [49].

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143 2.3. Statistics

144 The data was analyzed with IBM Statistical Package for the Social Sciences (SPSS) (Version 26.0).
145 Initially, principal component analysis of the 15 sleep questions was used to extract the sleep factors.
146 Subsequently, General Linear Model Multivariate Analysis of Variance (MANOVA) was utilized to

147 identify the effects of childhood trauma and stressful life events on sleep factors (dependent
 148 variables) after controlling for gender, parental education and psychiatric symptoms (anxiety and
 149 depressive symptoms). The effect sizes of the stress measures and psychiatric symptoms on
 150 MANOVA's are represented as Partial Eta Squared (η^2) [50]. The estimates of the direction of effect
 151 size are represented in t-statistic.
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153 3. Results

154 The demographics of the sample are in Table 1.

155 **Table 1.** Demographics of the sample.

	Female	Male	Total/Average \pm SD	T test
Number	386	366	752	
Age (years)	13.48 \pm 1.01	13.49 \pm 1.03	13.48 \pm 1.02	t (750) = 0.05, p = 0.95
Pubertal status	3.51 \pm 0.98	3.27 \pm 0.93	3.39 \pm 0.96	t (750) = -3.35, p = .001
Race White - nonhispanic	194 (50.3 %)	187 (51.1 %)	381 (50.7 %)	
Hispanic	131 (33.9 %)	125 (34.2 %)	256 (34.0 %)	
Black	12 (3.1 %)	13 (3.6 %)	25 (3.3 %)	
Hispanic and White	33 (8.5 %)	22 (6.0 %)	55 (7.3 %)	
Others	16 (4.2 %)	19 (5.1 %)	35 (4.7 %)	
Education				t (750) = 1.28, p = 0.20
Less than 9 th grade	1 (0.3 %)	2 (0.5 %)	3 (0.4 %)	
9 th to 12 th grade (no diploma)	5 (1.3 %)	5 (1.4 %)	10 (1.3 %)	
High School Graduate (including GED)	34 (8.8 %)	35 (9.6 %)	69 (9.2 %)	
Some College, no degree	87 (22.5 %)	59 (16.1 %)	146 (19.4 %)	
Associates Degree	42 (10.9 %)	35 (9.6 %)	77 (10.2 %)	
Bachelor's degree	98 (25.4 %)	105 (28.7 %)	203 (27.0 %)	
Graduate or Professional degree	119 (30.8 %)	125 (34.2%)	244 (32.4 %)	
Adverse Childhood Experiences score (CTQ)	33.33 \pm 8.41	33.64 \pm 7.32	33.48 \pm 7.90	t (750) = 0.54, p = 0.58
Emotional abuse (CTQ)	7.73 \pm 3.18	7.24 \pm 2.57	7.49 \pm 2.91	t (750) = -2.30, p = 0.022*
Physical abuse (CTQ)	6.21 \pm 1.83	6.37 \pm 1.92	6.29 \pm 1.88	t (750) = 1.14, p = 0.255
Sexual abuse (CTQ)	5.27 \pm 1.45	5.17 \pm .836	5.22 \pm 1.19	t (750) = -1.23, p = 0.217
Emotional neglect (CTQ)	8.01. \pm 3.47	8.47 \pm 3.69	8.23 \pm 3.59	t (750) = 1.77, p = 0.076
Physical neglect (CTQ)	6.11 \pm 1.92	6.40 \pm 1.96	6.25 \pm 1.95	t (750) = 2.02, p = 0.043*
Stressful life events subjective score (SLES)	140.76 \pm 174.35	84.93 \pm 122.66	113.59 \pm 153.87	t (750) = -5.05, p = 0.000***
Stressful life events objective score (SLES)	55.52 \pm 59.06	36.84 \pm 44.03	46.41 \pm 53.05	t (750) = -4.89, p = 0.000***
Anxiety symptoms (SCARED)	19.38 \pm 11.25	14.11 \pm 9.76	16.81 \pm 10.87	t (750) = -6.84, p = 0.000***
Depressive symptoms (MFQ)	11.86 \pm 10.62	8.90 \pm 8.27	10.42 \pm 9.66	t (750) = -4.40, p = 0.000***

Significance levels * - p \leq .05, ** - p \leq .001, *** - p \leq .0001

156

157 Demographic characteristics of the sample

158 256/752 (34%) of the adolescents were of Hispanic origin. The Hispanic or Latino ethnicity
 159 comprises 46% of the population in the San Antonio area. Participants were similarly matched for
 160 age, race, and parental education by gender. Females scored significantly higher subjective stress t
 161 (750) = - 5.05, p = 0.000, and objective stress t (750) = - 4.89, p = 0.000 on SLES and higher anxiety
 162 symptoms t (750) = - 6.84, p = 0.000 and depressive symptoms t (750) = - 4.40, p = 0.000) than males.

163 48/752 (6.2%) of the adolescents met criteria for emotional abuse, 44/752 (5.9%) met criteria for
 164 physical abuse, 23/752 (3.1%) met criteria for sexual abuse, 35/752 (4.7%) met criteria for emotional
 165 neglect and 58/752 (7.7%) met criteria for physical neglect. 42/752 (5.6%) had a score greater than 27
 166 on Mood and Feelings Questionnaire and 164/752 (21.8%) had a score greater than 25 for anxiety
 167 symptoms.

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 169 3.1. Principal component analysis of sleep questions

170 Principal Component Analysis of 15 sleep questions on varimax rotation separated into four
 171 factors with an eigenvalue greater than 1 and accounted for 52.09 % of the overall variance (see Table
 172 2).
 173

Table 2: Principal Component Analysis of sleep questions

	Factor 1	Factor 2	Factor 3	Factor 4
	Movement	Sleep	Sleep disturbances	Sleep pressure
	during sleep	regularity		
I move a great deal in my sleep (DOTS)	0.825			
I move a lot in bed (DOTS)	0.862			
In the morning I am in the same place as I fell asleep (DOTS)	-0.597			
I don't move around much at all in my sleep (DOTS)	-0.835			
I usually get the same amount of sleep each night (DOTS)		0.546		
I get sleepy just about the same time each night (DOTS)		0.601		
When I am away from home, I wake up at the same time each morning (DOTS)		0.686		
No matter when I go to sleep I wake up at the same time next morning (DOTS)		0.724		
I wake up at the same time on weekends and holidays as on other days of the week (DOTS)		0.673		
I sleep less than most kids (YSR)			0.801	
I have trouble sleeping (YSR)			0.682	
I have nightmares (YSR)			0.409	
I wake up at different times (DOTS)				0.426
I take a nap, rest or break at the same time every day (DOTS)				0.618

I sleep more than most kids during day
and/or night (YSR)

0.742

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The coefficients with absolute values less than 0.4 were suppressed. Of the four factors, Factor 1 explained 17.41% of the variance and loaded questions that assessed movement while asleep and movement in bed. Factor 2 explained 15.60% of the variance and loaded questions that assessed regularity of wake-up time, bedtime and regularity of becoming sleepy. Factor 3 explained 10.97% of the variance and loaded questions that assessed sleep disturbances including less sleep, trouble sleeping and nightmares. Factor 4 explained 8.10% of the variance and loaded questions that assessed the need for more sleep, taking naps, and waking at different times (Table 2). The Regression based factor scores of the four sleep factors were used as dependent sleep scores for further analyses.

3.2. Effects of gender, age, race and education on sleep factors

Initially, we identified the individual effects of the demographic variables of gender, age, race, education and pubertal status on the identified sleep factors. In these analyses, female gender was significantly associated with high Factor 1 ($F_{1,750} = 14.05$, $t = 3.74$, $p = 0.000$, $\eta^2 = 0.018$) and low Factor 2 scores ($F_{1,750} = 7.40$, $t = -2.72$, $p = 0.007$, $\eta^2 = 0.01$). High parental education was associated with high Factor 2 scores (regularity of sleep) ($F_{1,750} = 11.12$, $t = 3.33$, $p = 0.001$, $\eta^2 = 0.015$).

Age, race and advanced pubertal status were not significantly associated with any of the sleep factors and were not included in further analyses.

Subsequently, we utilized two models to identify the effects of stress. The first model identified the impact of stress (childhood trauma and stressful life events) on the identified sleep factors after controlling for gender and education of parent. The second model identified the effects of stress (childhood trauma and stressful life events) on the sleep factors after controlling for anxiety and depressive symptoms, gender and education.

3.3. First model to identify the effects of childhood trauma and stressful life events on sleep patterns after controlling for gender and parent education

Table 3: Childhood trauma and stressful life events effects on sleep patterns

	Factor 1 Movement during sleep	Factor 2 Sleep regularity	Factor 3 Sleep disturbances	Factor 4 Sleep pressure
Gender	11.15 (p = 0.001***)	6.57 (p = 0.011*)	.437 (p = 0.509)	0.160 (p = 0.689)
Education	1.41 (p = 0.235)	7.60 (p = 0.006**)	1.77 (p = 0.184)	3.36 (p = 0.067)
Childhood Adversity (CTQ Score)	1.53 (p = 0.216)	10.09 (p = 0.002**)	52.81 (p = 0.000***)	0.003 (p = 0.957)
Stressful Life Events (SLES Score)	5.29 (p = 0.022*)	0.148 (p = 0.700)	28.99 (p = 0.000***)	4.16 (p = 0.042)

Significance levels * - $p \leq .05$, ** - $p \leq .001$, *** - $p \leq .0001$

The corrected model was significant for Factor 1 ($F_{4,750} = 6.0$, $p = 0.000$, $\eta^2 = 0.031$), Factor 2 ($F_{4,750} = 7.42$, $p = 0.000$, $\eta^2 = 0.038$) and Factor 3 ($F_{4,750} = 27.65$, $p = 0.000$, $\eta^2 = 0.129$). Factor 4 was not significant ($F_{4,750} = 2.15$, $p = 0.072$, $\eta^2 = 0.011$).

In this model, high childhood trauma was significantly associated with high Factor 3 scores ($F_{1,750} = 52.81$, $t = 7.26$, $p = 0.000$, $\eta^2 = 0.066$) and low Factor 2 scores ($F_{1,750} = 10.09$, $t = -3.17$, $p = 0.002$, $\eta^2 = 0.013$). Similarly, a high stressful life events score was significantly associated with high Factor 3 scores ($F_{1,750} = 28.99$, $t = 5.38$, $p = 0.000$, $\eta^2 = 0.037$), high Factor 1 scores ($F_{1,750} = 5.29$, $t = 2.30$, $p =$

208 0.022, $\eta^2 = 0.007$) and high Factor 4 scores ($F_{1,750} = 4.16$, $t = 2.04$, $p = 0.042$, $\eta^2 = 0.006$). The stress
209 measures were not significantly associated with any of the other factors (Table 3).

210 Female gender in this model was associated with high Factor 1 scores ($F_{1,750} = 11.15$, $t = 3.34$,
211 $p = 0.001$, $\eta^2 = 0.015$) and low Factor 2 scores ($F_{1,750} = 6.57$, $t = -2.56$, $p = 0.011$, $\eta^2 = 0.009$). High parental
212 education was associated with high Factor 2 scores ($F_{1,750} = 7.60$, $t = 2.75$, $p = 0.006$, $\eta^2 = 0.01$). Gender
213 and education were not significantly associated with any of the other factors (Table 3).

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215 3.4. Second model to identify the effects of childhood trauma and stressful life events on sleep factors
216 after controlling for anxiety and depressive symptoms and gender and education

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Table 4: Childhood trauma, stressful life events and mental health symptoms effects on sleep patterns

	Factor 1 Movement during sleep	Factor 2 Sleep regularity	Factor 3 Sleep disturbances	Factor 4 Sleep pressure
Gender	5.69 (p = 0.017*)	8.09 (p = 0.005**)	1.84 (p = 0.175)	0.112 (p = 0.737)
Education	1.42 (p = 0.234)	7.62 (p = 0.006)	1.85 (p = 0.173)	3.46 (p = 0.063)
Childhood Adversity (CTQ Score)	0.029 (p = 0.864)	9.43 (p = 0.002**)	10.90 (p = 0.001**)	1.13 (p = 0.288)
Stressful Life Events (SLES Score)	1.36 (p = 0.243)	0.541 (p = 0.462)	7.76 (p = 0.005**)	1.13 (p = 0.287)
Anxiety symptoms score	10.04 (p = 0.002**)	2.29 (p = 0.130)	17.30 (p = 0.000***)	4.34 (p = 0.038)
Depressive symptoms score	0.272 (p = 0.602)	0.082 (p = 0.775)	31.09 (p = 0.000***)	1.20 (p = 0.273)

Significance levels * - $p \leq .05$, ** - $p \leq .001$, *** - $p \leq .0001$

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219 The corrected model was significant for all the sleep factors: Factor 1 ($F_{6,750} = 7.05$, $p = 0.000$, $\eta^2 = 0.054$),
220 Factor 2 ($F_{6,750} = 5.41$, $p = 0.001$, $\eta^2 = 0.042$), Factor 3 ($F_{6,750} = 39.18$, $p = 0.000$, $\eta^2 = 0.240$)
221 and Factor 4 ($F_{6,750} = 3.42$, $p = 0.002$, $\eta^2 = 0.027$).

222 Childhood trauma score continued to be significantly associated with high Factor 3 scores ($F_{1,750}$
223 $= 10.90$, $t = 3.30$, $p = 0.001$, $\eta^2 = 0.014$) and low Factor 2 scores ($F_{1,750} = 9.43$, $t = -3.07$, $p = 0.002$, $\eta^2 =$
224 0.013). The Stressful life events score was significantly associated with high Factor 3 scores ($F_{1,750} =$
225 7.76 , $t = 2.78$, $p = 0.005$, $\eta^2 = 0.01$) and was not associated with the other sleep factors.. The effect
226 sizes of stress measures were lower in this model with the inclusion of psychiatric symptoms (Table
227 4)

228 High anxiety symptoms in this model were significantly associated with high Factor 3 scores ($F_{1,750}$
229 $= 17.30$, $t = 4.16$, $p = 0.000$, $\eta^2 = 0.023$), high Factor 1 scores ($F_{1,750} = 10.04$, $t = 3.17$, $p = 0.002$, $\eta^2 =$
230 $.013$) and high Factor 4 scores ($F_{1,750} = 4.34$, $t = 2.08$, $p = 0.038$, $\eta^2 = 0.006$). High depressive symptom
231 score was significantly associated with high Factor 3 scores ($F_{1,750} = 31.09$, $t = 5.57$, $p = 0.000$, $\eta^2 =$
232 0.040). Anxiety and depressive symptoms were not significantly associated with the other sleep
233 factors (Table 4).

234 Female gender in the combined model continued to be significantly associated with low Factor
235 2 scores ($F_{1,750} = 8.09$, $t = -2.84$, $p = 0.005$, $\eta^2 = 0.011$) and high Factor 1 scores ($F_{1,750} = 5.69$, $t = 2.38$, $p =$
236 0.017 , $\eta^2 = 0.008$). High parental education continued to be significantly associated with high Factor
237 2 scores ($F_{1,750} = 7.62$, $t = 2.76$, $p = 0.006$, $\eta^2 = 0.010$). Gender and education were not significantly
238 associated with any of the other sleep factors (Table 4).

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240 3.5. Correlations between childhood trauma, stressful life events and anxiety and depressive
241 symptom scores

242 Childhood trauma score was significantly correlated with anxiety symptoms score ($r(752) =$
243 $0.245, p = 0.000$) and depressive symptoms score ($r(752) = 0.457, p = 0.000$). Stressful life events score
244 had a significant correlation with anxiety symptoms score ($r(752) = 0.323, p = 0.000$) and depressive
245 symptoms score ($r(752) = 0.334, p = 0.000$). Childhood trauma score and stressful life events score
246 were correlated ($r(752) = 0.242, p = 0.000$) and anxiety symptoms score was highly correlated with
247 depressive symptoms score ($r(752) = 0.634, p = 0.000$).

248 4. Discussion

249 We evaluated the role of childhood trauma and stressful life events on sleep patterns. We identified
250 four sleep factors—the movement during sleep, the regularity of sleep, sleep disturbances and sleep
251 pressure. Movement during sleep (Factor 1) originated from questions related to moving in bed and
252 moving during sleep; regularity of sleep (Factor 2) from regularity of bedtime and wake time; sleep
253 disturbances (Factor 3) from questions on sleeping less, trouble sleeping and nightmares; and sleep
254 pressure (Factor 4) from questions on sleeping more, needing naps and waking up at different times.
255 Sleep movement [51,52], regularity of sleep [53,54], sleep disturbances [18] and sleep pressure [55]
256 were used in sleep research to evaluate sleep patterns.

257 Childhood trauma was significantly associated with Factor 3 (sleep disturbances) after
258 controlling for anxiety and depressive symptoms scores. Factor 3 score originated from questions
259 related to nightmares, sleeping less and difficulty sleeping which commonly arise [56] and may
260 persist after the traumatic event. It is interesting to note that the effect size of childhood trauma on
261 sleep disturbances (Factor 3) decreased after anxiety and depressive symptoms were included. It is
262 likely that common mechanisms of sleep disruption underlie trauma and mental health symptoms.
263 Our results are similar to the findings of Noll et al. where female adolescents who suffered sexual
264 abuse had disturbed sleep after controlling for PTSD and depression [57]. It is pertinent to note that
265 childhood trauma scores in this sample were comparable to a community sample [58] and were lower
266 than an adolescent psychiatric inpatient population [41], suggesting the effects of childhood trauma
267 on sleep manifest even at lower levels of trauma.

268 Similar to childhood trauma, stressful life events in the past year were significantly associated
269 with high Factor 3 scores (sleep disturbances) that persist after controlling for anxiety and depressive
270 symptoms. These findings are in line with research that identified stressful life events are associated
271 with sleep disturbances [19,20]. The effect size of stressful life events on sleep disturbances was lower
272 than childhood trauma, suggesting the severity of stress plays a critical role in the severity of sleep
273 disturbances. The co-occurrence of childhood trauma and stressful life events was reported in some
274 studies and not in others [15]. The effect of stress, both childhood trauma and stressful life events,
275 albeit varied may present through a maladaptive Hypothalamus – Pituitary – Adrenal (HPA) system.
276 Childhood trauma and stressful life events activate the limbic system that, in turn, activate the HPA
277 axis through its projections into the hypothalamus and release the hormones corticotropin-releasing
278 hormone (CRH) and adrenocorticotrophic hormone (ACTH). CRH activates the fast acting
279 sympathetic-adrenal-medullary system and releases epinephrine in the prefrontal cortex known to
280 increase attention and vigilance, and adrenocorticotrophic hormone (ACTH) releases glucocorticoids
281 from the adrenal cortex. Heightened vigilance and arousal after stress may contribute to sleep
282 disturbance. Laboratory studies have shown that maltreated children and adolescents continue to
283 have increased hypervigilance as they respond to perceived potential social threats [59].

284 Additionally, anxiety symptoms were significantly associated with high Factor 1 (sleep
285 movement), high Factor 3 (sleep disturbances), high Factor 4 (sleep need) and depressive symptoms
286 associated with high Factor 3 (sleep disturbances). In previous studies, anxiety and depression
287 symptoms are associated with sleep disturbances in adolescents [18,60]. Evidence suggests that sleep
288 problems and anxiety may manifest together in early adolescence [61] and high movement during
289 sleep was observed in studies of anxiety [62]. The above-proposed model of dysregulation of the
290 HPA axis, including the sympathetic system and high glucocorticoids, is implicated in the

291 pathophysiology of insomnia [63], anxiety [30] and depressive symptoms [31]. Future studies should
292 explore the common biological pathways underlying the HPA axis and their variability between
293 stress, sleep, anxiety and depressive symptoms need to be further explored [18,64].

294 Female gender is significantly associated with increased movement during sleep and decreased
295 regularity of sleep. The gender-specific finding of increased disruption of sleep in female adolescents
296 in this study is likely related to the advanced pubertal status of female adolescents when compared
297 to males in this study. Previous studies have shown female specific increases in sleep problems in
298 adolescents with advanced pubertal status [65]. High parental education was significantly associated
299 with high regularity of sleep. High parental education is associated with earlier bedtime schedules
300 for children [66]. Parentally established bedtimes [67] improve the regularity of sleep by creating
301 regular sleep schedules for adolescents.

302 This analysis is a secondary analysis of cross-sectional self-reports and has important limitations.
303 We did not have objective measures for sleep and used self-report questionnaires. The four identified
304 sleep factors assessing sleep movement, sleep regularity, sleep disturbance and sleep pressure were
305 unique. Some degree of association exists between the sleep factors, as sleep habits influence the
306 quality of sleep [68], and poor sleep quality and irregular sleep patterns are associated with increased
307 sleep pressure [69,70]. The temporal associations between the sleep factors cannot be identified in
308 this analysis because of the cross-sectional nature of the observations. Also, collinearity, although not
309 approaching a high correlation, was observed for stress and anxiety and depressive symptoms,
310 suggesting associations between the answers on reported questionnaires. Future research that
311 includes objective measures of stress may help reduce the associations observed in self-report
312 measures. Lastly, we do not have information about the circadian preferences of the adolescents in
313 our sample, which may be relevant given that adolescents with evening type sleep preferences have
314 increased depressive and anxiety symptoms [71].

315 In summary, we identified that childhood trauma and stressful life events are independently
316 associated with sleep disturbances, and these effects persist after controlling for anxiety and
317 depressive symptoms in a large cohort of adolescents. Future research should include objective
318 measures to identify the complex relationships between stress, anxiety, depression and sleep while
319 focusing on circadian, neurobiological and social factors [18]. Understanding the common cognitive
320 and physiological pathways and their variability in stress, psychiatric and sleep symptoms can lead
321 to improved understanding of the development of sleep disturbances in adolescents with stress and
322 affective problems.

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334 **References**

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