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## Article

# Association of Sleep Quality, Sleep Disturbances, and Chronotype with Post-Traumatic Stress Disorder in Earthquake-Exposed Adolescents

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## Highlights

### What are the main findings?

- Adolescents with PTSD after the 2023 Türkiye earthquakes exhibited poorer sleep quality and more pronounced sleep problems than earthquake-exposed controls.
- Sleep quality impairment and clinically significant sleep problems were independently associated with PTSD status and correlated with symptom severity.
- Evening chronotype was more frequent in adolescents with PTSD and associated with symptom severity but was not independently linked to PTSD in multivariable analyses.

### What is the implication of the main finding?

- Routine assessment of sleep disturbances may help identify adolescents at risk for persistent PTSD symptoms after disasters.
- Interventions targeting sleep, including cognitive behavioral therapy for insomnia and nightmare-focused treatments, may improve sleep outcomes and reduce PTSD symptom severity.

## Abstract

Post-traumatic stress disorder (PTSD) is a frequent psychiatric outcome following trauma, and adolescents may be particularly vulnerable. This cross-sectional study investigated the associations between PTSD, sleep quality, sleep problems, and chronotype in earthquake-exposed adolescents. The sample comprised 201 adolescents aged 12–18 years: 92 with PTSD and 109 earthquake-exposed controls without a DSM-5 psychiatric diagnosis. Participants completed the Children's Posttraumatic Stress Reaction Index (CPTS-RI), Pittsburgh Sleep Quality Index (PSQI), Children's Sleep Habits Questionnaire (CSHQ), and Children's Chronotype Questionnaire (CCTQ). Adolescents with PTSD had significantly higher CPTS-RI, PSQI, CSHQ, and CCTQ scores compared with controls (all  $p < 0.001$ ), indicating poorer sleep quality, more sleep problems, and greater eveningness tendency. Correlation analyses showed that PTSD severity was positively associated with sleep problems, impaired sleep quality, and eveningness. In binary logistic regression analysis, poor sleep quality ( $p < 0.001$ ) and clinically significant sleep problems ( $p = 0.011$ ) were independently associated with PTSD, whereas chronotype was not. Sleep disturbances appear to be more strongly related to PTSD than chronotype itself. Assessment and treatment of sleep problems may represent an important therapeutic target in adolescents exposed to large-scale trauma.

**Keywords:** post-traumatic stress disorder; adolescence; sleep quality; chronotype; sleep disturbance; earthquake

## 1. Introduction

Exposure to or witnessing events such as war, accidents, natural disasters, or sexual assault elicits a stress response in everyone, but in some individuals, it leads to post-traumatic stress disorder (PTSD). PTSD is the most common psychiatric disorder following trauma and is characterized by re-experiencing, avoidance, negative alterations in cognition and mood, and hyperarousal symptoms [1]. In addition to individual characteristics such as sex, prior traumatic experiences, and a history of psychiatric illness, trauma-related factors including trauma severity, perceived threat to life, and injury also contribute to risk [2]. Compared with adults, children and adolescents are at higher risk of both exposure and developing the disorder [3]. Because cognitive and emotional maturation is ongoing, adolescence may be accompanied by greater functional impairment due to increased vulnerability to trauma [4]. Clinically, although the cognitive, emotional, behavioral, and somatic symptoms of PTSD in adolescents resemble those in adults, the disorder can severely affect psychosocial, academic, and emotional development in this age group [5]. The prevalence among trauma-exposed children and adolescents has been reported as 15.9%, and this rate has been shown to increase after mass traumas [6].

Studies on the pathophysiology of PTSD suggest that sleep and circadian rhythm disturbances are integral to symptom expression and maintenance. Moreover, evidence from prospective work indicates that pre-trauma sleep problems may be associated with increased vulnerability to trauma-related disorders [7]. From a mechanistic perspective, sleep is thought to support the restoration and recalibration of neuronal networks essential for adaptive functioning [8]. Sleep disruption can adversely affect cognitive performance and mood and contribute to daytime fatigue, which may further amplify distress and functional impairment in PTSD [9]. The initiation and maintenance of sleep are regulated by the interaction between sleep–wake homeostasis and the circadian timing system. In PTSD, hyperarousal and stress-related circadian phase shifts may disrupt the sleep–wake cycle and alter sleep architecture [10].

Sleep-related problems listed in the DSM-5 PTSD diagnostic criteria are among the most common reasons for clinical presentation [1]. PTSD is associated with a range of sleep problems, including insomnia, nightmares, periodic limb movements, sleep apnea, excessive daytime sleepiness, and sleep-related anxiety, with comorbidity rates reported as high as 90% in some studies [11]. Sleep problems have been proposed to impair fear extinction of conditioned fear responses and thereby contribute to PTSD development. Moreover, sleep problems have been shown to correlate with PTSD symptom severity [12].

Although sleep disturbances are considered a core clinical feature of PTSD, evidence is accumulating that the circadian system may influence both sleep quality and the development of post-traumatic psychopathology [13]. The circadian rhythm refers to an approximately 24-h cycle generated by the biological clock, synchronized by zeitgebers, and governing behavioral and physiological changes. Chronotype reflects individual differences in biological rhythms, including the sleep–wake cycle, body temperature, hormone levels, cognitive functions, and the timing of daily activities. These circadian and performance measures vary across individuals, and three chronotype groups are typically described: morning, intermediate, and evening types. Morning types tend to fall asleep earlier, wake earlier, and show better mental and physical performance earlier in the day. Evening types go to bed later, wake later, and show better performance later in the day, whereas individuals who do not fit morning or evening patterns are classified as intermediate types [14]. Chronotype changes with age, and eveningness tends to increase during adolescence [15].

Circadian rhythm disruption has been associated with psychiatric disorders, neurodevelopmental disorders, and several medical conditions. Misalignment between an individual's biological clocks and daily diurnal activities (e.g., school, work, or social obligations) is

often more pronounced in evening types and can contribute to circadian disruption [16]. Disrupted circadian rhythms in evening types can affect sleep quantity and quality, resulting in social jet lag and chronic stress [17]. In addition, evening types have been reported to show emotional dysregulation and lower behavioral activation [18]. Adult and adolescent studies examining the association between chronotype and psychiatric disorders have reported that mood disorders, sleep problems, and substance use disorders are more common among evening types [17,19].

In the limited number of adult studies examining the relationship between PTSD and the circadian system, evening chronotype has been reported as a potential risk factor [20–23]. However, other studies have reported no association between PTSD and evening chronotype [13,24]. In children and adolescents, there are only a few studies suggesting that sleep problems, circadian rhythm disturbances, and evening chronotype are associated with PTSD. In a study of 68 children and adolescents aged 8–17 years after Hurricane Harvey, evening chronotype and subjectively reported sleep problems were associated with post-traumatic stress symptoms, and higher levels of re-experiencing, hyperarousal, and cognitive distortions were observed. Short sleep duration assessed by actigraphy was associated with avoidance symptoms. The authors suggested that, together with evening chronotype, post-disaster hyperarousal may lead to sleep problems; as a result, disruption of sleep's role in emotional regulation may contribute to increased post-traumatic stress symptoms [25]. In another small study comparing PTSD cases aged 3–18 years with controls, sleep problems and evening-chronotype features were associated with PTSD [26]. Nevertheless, it remains unclear whether the chronotype–PTSD association is explained by sleep problems.

Considering the available literature, the number of studies in adolescents examining the association between PTSD and chronotype appears to be limited. Based on previous findings, we hypothesized that adolescents with PTSD would exhibit poorer sleep quality, more sleep problems, and a greater tendency toward evening chronotype compared with earthquake-exposed controls. Furthermore, we expected that sleep disturbances would independently predict PTSD status beyond chronotype characteristics. This study aimed to investigate these relationships and clarify the potential role of sleep-related factors in adolescent PTSD following earthquake exposure.

## 2. Materials and Methods

This was a cross-sectional case–control study designed to examine the relationships between post-traumatic stress disorder (PTSD), sleep quality, sleep problems, and chronotype in adolescents following earthquake exposure.

### 2.1. Participants

On 6 February 2023, the Kahramanmaraş Earthquake Sequence (Mw 7.8 and Mw 7.5) occurred in southern Türkiye and caused major destruction across eleven provinces. This disaster sequence affected more than 9.1 million people and resulted in over 51,000 deaths [27]. The present study was conducted among adolescents who presented to the İnönü University Faculty of Medicine, Department of Child and Adolescent Psychiatry outpatient clinic after the Kahramanmaraş Earthquake Sequence. The study protocol received ethical clearance from the İnönü University Clinical Research Ethics Committee (2023/70) and adhered to the principles outlined in the Declaration of Helsinki.

Earthquake-exposed adolescents aged 12–18 years were evaluated psychiatrically through face-to-face clinical interviews conducted by a child and adolescent psychiatrist with at least five years of clinical experience. According to DSM-5 diagnostic criteria, participants were then assigned to either the PTSD group or an earthquake-exposed control group without a DSM-5 psychiatric diagnosis. Participants and their parents were informed in detail about the study, and written informed consent was obtained before enrollment.



### 2.1.1. Inclusion Criteria

- a) Participants were included if they:
- b) were between 12 and 18 years of age,
- c) had been directly exposed to the Kahramanmaraş Earthquake Sequence,
- d) presented to the child and adolescent psychiatry outpatient clinic for psychiatric evaluation, and
- e) provided written informed consent from both the adolescent and at least one parent/legal guardian.

### 2.1.2. Exclusion Criteria

- a) Participants were excluded if they had:
- b) autism spectrum disorder,
- c) psychotic disorder,
- d) bipolar disorder,
- e) any psychiatric disorder known to affect circadian rhythms, or
- f) any chronic medical illness.

## 2.2. Measures

### 2.2.1. Sociodemographic Questionnaire

The sociodemographic questionnaire was developed by the researchers and included questions to obtain demographic information (age, sex, education level, family structure, and economic status) as well as earthquake-related questions.

### 2.2.2. Children's Posttraumatic Stress Reaction Index (CPTS-RI)

The CPTS-RI is a 20-item, 5-point Likert-type self-report measure used to assess PTSD symptoms that develop after a traumatic event. Each item is scored from 0 to 4, and items 7, 12, and 15 are reverse scored. Based on total scores, symptoms are classified as mild (12–24), moderate (25–39), severe (40–59), and very severe ( $\geq 60$ ) [28]. The validity and reliability of the Turkish version were evaluated by Erden and colleagues in 1999 [29]. In that study, test-retest reliability was 0.86, Cronbach's alpha was 0.75, and inter-rater agreement (kappa) was 0.887. All items refer to a specific traumatic event; in the present study, the traumatic event was the Kahramanmaraş Earthquake Sequence (Mw 7.8 and Mw 7.5) that occurred in southern Türkiye on 6 February 2023.

### 2.2.3. Children's Sleep Habits Questionnaire (CSHQ)

The CSHQ is a parent-reported questionnaire developed by Owens et al. to investigate sleep habits and sleep-related problems in school-aged children [30]. The scale demonstrated adequate internal consistency in both community and clinical samples. The 33-item questionnaire is typically coded as usually (behavior occurs 5–7 times per week) = 3, sometimes (2–4 times per week) = 2, and rarely (0–1 time per week) = 1; items 1, 2, 3, 10, 11, and 26 are reverse coded (usually = 1, sometimes = 2, rarely = 3). A total score of 41 is commonly used as a cutoff, with values above this threshold interpreted as clinically significant sleep problems. The Turkish validity and reliability of the short form were evaluated by Fiş and colleagues, with test-retest reliability of 0.81 and Cronbach's alpha of 0.78 [31].

### 2.2.4. Pittsburgh Sleep Quality Index (PSQI)

The PSQI is a measure developed by Buysse et al. to assess sleep quality based on sleep habits, sleep problems, and their impact on daytime functioning [32]. It is a 19-item self-report scale assessing subjective sleep quality over the past month, with a total score ranging from 0 to 21; scores  $> 5$  are associated with poor sleep quality. The Turkish validity and reliability study was conducted by Ağargün and colleagues [33].

2.2.5. Children’s Chronotype Questionnaire (CCTQ)

The CCTQ is a 27-item parent-report questionnaire comprising 16 items assessing sleep–wake parameters on scheduled days and free days, a 10-item morningness–eveningness scale, and a final item evaluating chronotype. Items 17–26 are rated on a 5-point scale (1–5). In the final item (Item 27), parents classify their child’s chronotype by selecting one of the following options: “Definitely a Morning Type,” “Rather a Morning Type than an Evening Type,” “Neither a Morning nor an Evening Type,” “Rather an Evening Type than a Morning Type,” “Definitely an Evening Type,” or “I do not know.” Items 17, 18, 24, and 25 are reverse-scored, yielding a total morningness–eveningness score ranging from 10 to 48; scores  $\leq 23$  indicate morning type, 24–32 intermediate type, and  $\geq 33$  evening type [34]. The Turkish validity and reliability study was conducted by Dursun et al., who reported a Cronbach’s alpha of 0.65 [35].

2.3. Statistical Analysis

An a priori power analysis was conducted using G\*Power 3.1. Assuming a medium effect size ( $d = 0.5$ ),  $\alpha = 0.05$ , and power  $(1-\beta) = 0.80$ , the minimum required sample size was 128 participants. The final sample size of 201 participants exceeded this requirement.

Data analysis was performed using SPSS version 22.0. Descriptive statistics were presented as mean  $\pm$  standard deviation, number, and percentage. Data distribution was assessed using the Shapiro–Wilk test. For parametric data, the independent-samples t-test was used, and Pearson’s chi-square test or Fisher’s exact test was applied for categorical variables, as appropriate. Associations between variables were evaluated using Pearson correlation analysis. Multicollinearity was assessed using variance inflation factor (VIF) values before regression analyses, and no significant multicollinearity was detected. The relationship between PTSD and sleep quality, sleep problems, and chronotype was tested using binary logistic regression analysis. P value  $< 0.05$  was considered statistically significant.

3. Results

A total of 201 adolescents participated in the study: 92 in the PTSD group and 109 in the control group. The mean age was  $15.30 \pm 2.04$  years in the PTSD group and  $14.80 \pm 1.87$  years in the control group. The PTSD group included 60 girls (65.2%) and 32 boys (34.8%), whereas the control group included 60 girls (55.0%) and 49 boys (45.0%).

There were no significant between-group differences in age, sex, place of residence, income level, parental psychiatric history, earthquake-related home damage, or earthquake-related bereavement. When post-earthquake accommodation was considered, the PTSD group reported a lower rate of out-of-province accommodation compared with the control group ( $p = 0.035$ ). Sociodemographic and earthquake-related data are presented in Table 1.

Table 1. Comparison of sociodemographic and earthquake-related variables.

|                          |                    | PTSD Group       |      | Control Group    |      | F              | p <sup>a</sup> |
|--------------------------|--------------------|------------------|------|------------------|------|----------------|----------------|
| Age (Mean $\pm$ SD)      |                    | 15.30 $\pm$ 2.04 |      | 14.80 $\pm$ 1.87 |      | 2.154          | 0.069          |
|                          |                    | n                | %    | n                | %    | X <sup>2</sup> | p <sup>b</sup> |
| Gender                   | Female             | 60               | 65.2 | 60               | 55.0 | 2.145          | 0.152          |
|                          | Male               | 32               | 34.8 | 49               | 45.0 |                |                |
| Place of Residence       | City Center        | 69               | 75.0 | 81               | 74.3 | 1.948          | 0.378          |
|                          | District           | 13               | 14.1 | 21               | 19.3 |                |                |
|                          | Rural Area         | 10               | 10.9 | 7                | 6.4  |                |                |
| Monthly Household Income | Below Minimum Wage | 8                | 8.7  | 11               | 10.2 | 0.291          | 0.864          |
|                          | Minimum Wage       | 23               | 25.0 | 24               | 22.2 |                |                |
|                          | Above Minimum Wage | 61               | 66.3 | 73               | 67.6 |                |                |

|                                                    |                 |    |      |     |      |       |        |
|----------------------------------------------------|-----------------|----|------|-----|------|-------|--------|
| Parental Psychiatric Disorder                      | No              | 83 | 90.2 | 103 | 94.5 | 1.322 | 0.289  |
|                                                    | Yes             | 9  | 9.8  | 6   | 5.5  |       |        |
| Earthquake-related Damage to Home                  | No Damage       | 14 | 15.2 | 22  | 20.4 | 5.581 | 0.233  |
|                                                    | Mild Damage     | 57 | 62.0 | 52  | 48.1 |       |        |
|                                                    | Moderate Damage | 7  | 7.6  | 14  | 13.0 |       |        |
|                                                    | Severe Damage   | 13 | 14.1 | 20  | 18.5 |       |        |
| Bereavement Due to the Earthquake                  | No              | 85 | 92.4 | 102 | 94.4 | 0.345 | 0.579  |
|                                                    | Yes             | 7  | 7.6  | 6   | 5.6  |       |        |
| Out-of-province Accommodation After the Earthquake | No              | 36 | 40.0 | 28  | 25.9 | 4.445 | 0.047* |
|                                                    | Yes             | 54 | 60.0 | 80  | 74.1 |       |        |

p<sup>a</sup> values are from the independent-samples t-test. p<sup>b</sup> values are from chi-square analysis. \*p < 0.05.

There were statistically significant between-group differences in CPTS-RI (post-traumatic stress severity), PSQI (sleep quality), CSHQ (sleep problems), and CCTQ (chronotype) scores (all p < 0.001). Compared with the control group, the PTSD group had higher mean CPTS-RI, PSQI, CSHQ, and CCTQ scores. Scale score data are presented in Table 2.

Table 2. Comparison of CPTS-RI, PSQI, CSHQ, and CCTQ scores.

|               | PTSD Group (Mean ± SD) | Control Group (Mean ± SD) | F      | p       |
|---------------|------------------------|---------------------------|--------|---------|
| CPTS-RI Score | 51.88 ± 8.64           | 21.62 ± 10.27             | 5.719  | <0.001* |
| PSQI Score    | 8.76 ± 3.50            | 4.32 ± 2.72               | 6.592  | <0.001* |
| CSHQ Score    | 50.72 ± 9.92           | 42.50 ± 6.96              | 10.898 | <0.001* |
| CCTQ Score    | 33.35 ± 5.18           | 29.96 ± 5.39              | 0.411  | <0.001* |

p values are from independent-samples t-tests. CPTS-RI: Children’s Posttraumatic Stress Reaction Index. PSQI: Pittsburgh Sleep Quality Index. CSHQ: Children’s Sleep Habits Questionnaire. CCTQ: Children’s Chronotype Questionnaire. \*p < 0.001.

Based on CPTS-RI scores in the PTSD group, 74 participants (80.4%) had severe symptoms and 18 (19.6%) had very severe symptoms. Symptom-severity categories differed between groups (p < 0.001). Regarding chronotype, the intermediate type was more common in the control group, whereas the evening type was more prevalent in the PTSD group (p < 0.001).

There were marked differences between the PTSD and control groups in sleep quality and sleep problems. Adolescents with PTSD reported poorer sleep quality and more sleep problems (p < 0.001). Restlessness during sleep and nightmares were more frequent in the PTSD group (p < 0.001 and p = 0.005, respectively). Analyses of CPTS-RI, CCTQ, PSQI, and CSHQ-related data are presented in Table 3.

Table 3. Comparison of CPTS-RI, CCTQ, PSQI, and CSHQ-related categorical variables.

|                                        |                   | PTSD Group      |      | Control Group   |      | X <sup>2</sup> | p       |
|----------------------------------------|-------------------|-----------------|------|-----------------|------|----------------|---------|
|                                        |                   | n               | %    | n               | %    |                |         |
| Posttraumatic Stress Reaction Severity | No                | 0               | 0    | 23              | 21.1 | 201.000        | <0.001* |
|                                        | Mild              | 0 <sup>b</sup>  | 0    | 43 <sup>a</sup> | 39.4 |                |         |
|                                        | Moderate          | 0 <sup>b</sup>  | 0    | 43 <sup>a</sup> | 39.4 |                |         |
|                                        | Severe            | 74 <sup>b</sup> | 80.4 | 0 <sup>a</sup>  | 0    |                |         |
|                                        | Very Severe       | 18 <sup>b</sup> | 19.6 | 0 <sup>a</sup>  | 0    |                |         |
| Chronotype                             | Morning type      | 4 <sup>a</sup>  | 4.3  | 13 <sup>a</sup> | 11.9 | 21.894         | <0.001* |
|                                        | Intermediate type | 32 <sup>b</sup> | 34.8 | 65 <sup>a</sup> | 59.6 |                |         |
|                                        | Evening type      | 56 <sup>b</sup> | 60.9 | 31 <sup>a</sup> | 28.4 |                |         |
| Sleep Quality                          | Good              | 17              | 18.5 | 78              | 71.6 | 56.398         | <0.001* |
|                                        | Poor              | 75              | 81.5 | 31              | 28.4 |                |         |

|                                           |                            |                 |      |                 |      |        |         |
|-------------------------------------------|----------------------------|-----------------|------|-----------------|------|--------|---------|
| Clinical Significance Based on CSHQ Score | Not Clinically Significant | 15              | 16.3 | 51              | 46.8 | 21.023 | <0.001* |
|                                           | Clinically Significant     | 77              | 83.7 | 58              | 53.2 |        |         |
| Sleep Talking                             | Rarely                     | 62              | 67.4 | 81              | 74.3 | 1.430  | 0.489   |
|                                           | Sometimes                  | 23              | 25   | 23              | 21.1 |        |         |
|                                           | Usually                    | 7               | 7.6  | 5               | 4.6  |        |         |
| Restlessness and Movement During Sleep    | Rarely                     | 46 <sup>b</sup> | 50   | 77 <sup>a</sup> | 70.6 | 15.505 | <0.001* |
|                                           | Sometimes                  | 26 <sup>a</sup> | 28.3 | 27 <sup>a</sup> | 24.8 |        |         |
|                                           | Usually                    | 20 <sup>b</sup> | 21.7 | 5 <sup>a</sup>  | 4.6  |        |         |
| Teeth Grinding During Sleep               | Rarely                     | 75              | 81.5 | 91              | 83.5 | 0.372  | 0.830   |
|                                           | Sometimes                  | 12              | 13   | 14              | 12.8 |        |         |
|                                           | Usually                    | 5               | 5.5  | 4               | 3.7  |        |         |
| Waking Up Frightened Due to a Scary Dream | Rarely                     | 58 <sup>b</sup> | 63   | 88 <sup>a</sup> | 80.7 | 10.602 | 0.005*  |
|                                           | Sometimes                  | 22 <sup>a</sup> | 23.9 | 18 <sup>a</sup> | 16.5 |        |         |
|                                           | Usually                    | 12 <sup>b</sup> | 13   | 3 <sup>a</sup>  | 2.8  |        |         |

CSHQ: Children’s Sleep Habits Questionnaire. p values are from chi-square analyses. p values are from chi-square analysis. Superscripts a and b indicate statistically significant differences between the groups (p<0.05). \*p < 0.01.

Pearson correlation analyses showed that CPTS-RI, PSQI, CSHQ, and CCTQ scores were positively correlated with one another (all p < 0.001), indicating that greater PTSD symptom severity was associated with poorer sleep quality, more sleep problems, and a greater tendency toward eveningness. Correlation data are presented in Table 4.

**Table 4.** Correlation analysis of CPTS-RI, PSQI, CSHQ, and CCTQ scores.

|               | CPTS-RI Score | PSQI Score | CSHQ Score | CCTQ Score |
|---------------|---------------|------------|------------|------------|
| CPTS-RI Score | 1.000         | 0.642*     | 0.500*     | 0.275*     |
| PSQI Score    | -             | 1.000      | 0.507*     | 0.300*     |
| CSHQ Score    | -             | -          | 1.000      | 0.418*     |
| CCTQ Score    | -             | -          | -          | 1.000      |

CPTS-RI: Children’s Posttraumatic Stress Reaction Index. PSQI: Pittsburgh Sleep Quality Index. CSHQ: Children’s Sleep Habits Questionnaire. CCTQ: Children’s Chronotype Questionnaire. \*p < 0.001.

In binary logistic regression analyses, poor sleep quality and clinically significant sleep problems were independently associated with PTSD status (p < 0.001 and p = 0.011, respectively). Although chronotype differed between groups, chronotype characteristics were not independently associated with PTSD status. Logistic regression results are presented in Table 5.

**Table 5.** Binary logistic regression analysis of PSQI, CSHQ, and CCTQ variables.

|                                                                                                                | β     | OR    | 95% C.I. |        | p       |
|----------------------------------------------------------------------------------------------------------------|-------|-------|----------|--------|---------|
|                                                                                                                |       |       | Lower    | Upper  |         |
| Sleep Quality based on PSQI Score<br>0: Sleep quality not impaired<br>1: Sleep quality impaired<br>0→1         | 2.216 | 9.168 | 4.535    | 18.536 | <0.001* |
| Clinical Significance based on CSHQ Score<br>0: Not clinically significant<br>1: Clinically significant<br>0→1 | 1.051 | 2.860 | 1.269    | 6.441  | 0.011*  |
| Chronotype based on CCTQ<br>0: Morning type<br>1: Intermediate type<br>0→1                                     | 0.687 | 1.987 | 0.464    | 8.514  | 0.355   |
| Chronotype based on CCTQ                                                                                       | 0.010 | 1.011 | 0.243    | 4.207  | 0.989   |



---

0: Morning type  
2: Evening type  
0→2

---

PSQI: Pittsburgh Sleep Quality Index. CSHQ: Children’s Sleep Habits Questionnaire. CCTQ: Children’s Chronotype Questionnaire. Nagelkerke R2 = 0.418. \*p < 0.05.

4. Discussion

The present findings indicate that sleep disturbances are a prominent feature of adolescent PTSD following disaster exposure. Both impaired sleep quality and increased sleep problems were independently associated with PTSD and correlated with symptom severity. Although evening chronotype was more frequent among adolescents with PTSD and was associated with greater symptom severity, chronotype was not independently associated with PTSD in regression analyses. These findings suggest that sleep disturbances, rather than chronotype itself, may be more closely associated with PTSD among adolescents.

Poor sleep quality and sleep problems co-occur with many psychiatric disorders and are also considered among the core features of PTSD [11,36]. In PTSD, sleep quality may deteriorate due to hyperarousal, increased sleep disturbances, sleep-related anxiety, and disrupted circadian rhythms [37]. This contributes to persistence of PTSD symptoms and functional impairment, and a positive correlation has been reported between PTSD symptom severity and impaired sleep quality [38]. Studies in adolescents, similar to those in adults, show that trauma exposure is associated with poorer sleep quality [39,40]. Adolescents who developed PTSD after sexual assault have been reported to have poorer sleep quality than controls, and sleep problems were reported to affect quality of life more strongly than PTSD itself [41]. Moreover, sleep impairment may persist even after clinical improvement with psychotherapy or other treatments, suggesting that poor sleep quality and sleep problems can continue beyond other PTSD symptoms [42].

Individuals with PTSD frequently report reduced sleep quality, frequent awakenings, insomnia, nightmares, excessive daytime sleepiness, and impaired functioning [43]. Increased amygdala activity and dysregulated neuroendocrine systems after trauma have been proposed to contribute to insomnia via hyperarousal. High anxiety, rumination, and cognitive distortions may further increase hyperarousal and disrupt sleep quality [44]. Sleep is critical for emotional memory consolidation and stress regulation. Sleep disruption may impair effective fear extinction and has been linked to the development of intrusive thoughts and nightmares in PTSD [45]. PTSD-related nightmares have been reported to occur during disrupted REM sleep and light sleep stages, often accompanied by motor behaviors. Nightmares may also trigger sleep-related anxiety and exacerbate sleep problems [46]. Insomnia and nightmare disorder are commonly reported after trauma and have also been reported in studies of adolescents after earthquakes [40,47,48]. In the present study, the PTSD group had markedly poorer sleep quality and significantly more sleep problems than the control group. Correlation and binary logistic regression analyses indicated that PTSD symptom severity was associated with impaired sleep quality and sleep problems, and poor sleep quality and sleep problems were identified as independently associated with PTSD status.

Many studies have reported that chronotype may be associated with certain psychiatric problems, and eveningness has been linked to mood disorders, sleep disorders, attention-deficit/hyperactivity disorder, and substance use [49]. However, evidence regarding the relationship between evening chronotype and PTSD is derived largely from adult populations, and findings remain limited and inconsistent. Some studies examining the link between chronotype and PTSD have reported an association with eveningness. In a 2023 study including 120 adults and using the Trauma and Loss Spectrum–Self Report (TALS), PSQI, a short MEQ, and actigraphy, eveningness was associated with poorer sleep quality and higher TALS scores [50]. A twin study examined the relationship between PTSD and chronotype from a genetic perspective using the Impact of Events Scale (IES) and a short MEQ; it reported a significant association between eveningness and PTSD symptom severity in adults and suggested a partially causal genetic relationship [51]. Hasler et al.

also reported findings indicating that eveningness may be associated with poorer sleep quality and PTSD in adults [20]. In a study using the PTSD Checklist for DSM-5 (PCL-5), Dissociative Experiences Scale, PSQI, and MEQ, the dissociative PTSD group exhibited a greater tendency toward eveningness [52]. Another study investigated the impact of chronotype on PTSD among medical students after the 6 February Kahramanmaraş Earthquakes; after administration of the MEQ and PCL-5, participants with an evening chronotype reported higher PCL-5 scores than other types, and eveningness was discussed as a potential risk factor for PTSD [23]. However, other studies have reported no association between PTSD and eveningness [13,24]. In the meta-analysis by Zalta et al. examining sleep timing, chronotype, and PTSD, only two adult studies assessing the chronotype–PTSD relationship were included, and no clear association was identified [13]. In the present study, although correlation analyses suggested a possible association between eveningness and PTSD, binary logistic regression indicated that chronotype was not independently associated with PTSD status.

In the literature, the relationship between chronotype and PTSD is often explained by sleep problems [20,22]. During the COVID-19 quarantine, one study reported lower resilience and poorer sleep quality among evening types and suggested that sleep quality may mediate the relationship between resilience and post-traumatic stress responses [53]. In another study examining the effect of chronotype on post-traumatic stress symptoms, regression analyses indicated that impaired sleep quality may be associated with greater post-traumatic stress symptoms, whereas chronotype was not independently associated [50]. Our results appear largely consistent with these findings.

Taken together, our findings support the hypothesis that the relationship between chronotype and PTSD may be largely mediated by sleep disturbances. Eveningness may be associated with poorer sleep quality and increased sleep problems, which in turn are linked to PTSD symptoms. Therefore, chronotype itself may not constitute an independent correlate of PTSD but rather an indirect marker operating through sleep-related mechanisms.

These findings may have clinical implications. Assessment of sleep disturbances should be considered a routine component of the evaluation of adolescents with PTSD after disasters. Interventions targeting sleep problems, such as sleep hygiene education, cognitive behavioral therapy for insomnia, and nightmare-focused interventions, may contribute not only to improving sleep but also to reducing PTSD symptom severity. Therefore, sleep disturbances may represent a modifiable treatment target in adolescent PTSD.

Beyond trauma characteristics, socioeconomic and family factors also play an important role in PTSD development. Low income, disadvantaged environmental conditions, and parental psychiatric disorders have been described as PTSD risk factors [54]. Significant associations have been reported between parental psychological functioning and children's PTSD symptoms [55]. In the present study, groups were similar with respect to place of residence, household income, and parental psychiatric disorder. As with the sex-related findings, this finding may be related to the cross-sectional design and relatively small sample size.

As noted in the literature, female sex, living in rural areas, low household income, and parental psychiatric disorders are considered risk factors for PTSD. The primary aim of the present study was to examine the relationship between sleep problems, sleep quality, and chronotype in adolescents with PTSD, and it was not designed as an epidemiological study. In this context, between-group similarity in key sociodemographic variables that could act as confounders (age, sex, place of residence, income, and parental psychiatric disorder) increases the credibility of findings related to the study aims.

Several studies have reported that injury or bereavement after disasters may increase PTSD risk [56], and similar results have been reported after the Kahramanmaraş Earthquake Sequence [57,58]. In addition, material losses and earthquake-related home damage, which may reflect trauma severity, have also been reported as potential PTSD risk factors [59]. In the present study, there were no significant between-group differences in bereavement or home damage. This may be related to the

small number of participants who experienced bereavement. Moreover, given that much of the available literature focuses on adult populations, direct comparison may not be appropriate.

Adverse experiences and repeated traumas in the aftermath of an earthquake are associated with a higher risk of PTSD [56]. In the present study, residing in provinces not affected by the earthquake after the disaster was significantly more common in the control group than in the PTSD group. This pattern may reflect reduced exposure to trauma reminders, which have been linked to an increased risk of PTSD. Consistent with this interpretation, traumatic events occurring before or after an index trauma are associated with higher PTSD prevalence in adolescents [60]. Aftershocks persisted for a year following the Kahramanmaraş Earthquake Sequence, and ongoing residence in the epicenter or affected regions may involve recurrent exposure to smaller earthquakes and persistent reminders of destruction, which may disrupt normalization and recovery processes and limit access to effective psychosocial support, potentially contributing to PTSD.

Studies suggest that the highest risk of trauma exposure occurs between ages 16 and 20 years [61]. However, a 2024 systematic review and meta-analysis examining PTSD development after traumatic injuries suggested that age may be only a weak predictor [62]. In the meta-analysis by Tang et al. including earthquake-exposed children and adults, age was not reported as a PTSD risk factor after correction for publication bias [56]. In the present study, consistent with the findings of Tang et al., there was no significant age difference between the groups. Nevertheless, because only adolescents aged 12–18 years were evaluated and the study design is cross-sectional, it is not appropriate to make broad generalizations about the relationship between age and PTSD.

In the literature, the distribution of PTSD by sex is approximately 2:1 in favor of females. Studies of earthquake survivors have consistently found that women develop PTSD more frequently than men, and that PTSD severity and chronicity tend to be greater in women [63]. In the present study, the PTSD group was predominantly female (65.2%); however, no statistically significant sex difference was observed between groups, and our findings regarding sex differences should be interpreted cautiously. This discrepancy may be related to the cross-sectional design and the relatively small sample size.

This study has several limitations. First, due to the cross-sectional design, causal relationships between sleep disturbances and PTSD cannot be inferred, and longitudinal studies are required to clarify temporal directionality. Second, the single-center design and relatively modest sample size may limit generalizability. Nevertheless, the study also has notable strengths. It is one of the few studies examining the relationship between chronotype and PTSD in adolescents and incorporates specialist assessments of PTSD, sleep problems, and sleep quality. Furthermore, similarity between groups in sociodemographic variables that could act as confounders enabled a clearer evaluation of the relationships among sleep quality, sleep problems, chronotype, and PTSD. Future studies with larger samples and broader age ranges are warranted.

## 5. Conclusion

Adolescents with PTSD following the 2023 Türkiye earthquakes exhibited poorer sleep quality and more pronounced sleep problems than earthquake-exposed controls. Sleep quality impairment and clinically significant sleep problems were independently associated with PTSD status and correlated with symptom severity. Although evening chronotype was more frequent among adolescents with PTSD and related to greater symptom severity, it was not independently associated with PTSD in multivariable analyses. These findings indicate that the relationship between chronotype and PTSD may largely be explained by underlying sleep disturbances rather than a direct association. Systematic assessment of sleep and early interventions targeting sleep problems may therefore support recovery in adolescents exposed to large-scale traumatic events. Prospective longitudinal studies are required to clarify temporal relationships between sleep disturbances, chronotype, and PTSD in adolescence.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in this study.

**Data Availability Statement:** The data that support the findings of this study are available from the corresponding author (Y.E.D.), upon reasonable request.

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