Empirical Article

Sleep and childhood maltreatment: A matched-control study of sleep characteristics in Norwegian 16–19-year-olds

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Sleep problems are an important but understudied health problem in adolescents exposed to childhood maltreatment. The current study aimed to examine sleep characteristics and insomnia in a population with maltreatment history and compare them to a general population sample of adolescents. Data from a sample of Norwegian 16–19-year-old adolescents with childhood maltreatment experiences ($n = 62$) were linked to an age- and sex-matched general population sample ($n = 238$). Independent samples t tests were used to compare the two groups on several detailed sleep parameters, while general linear models were used to control for mental health problems, assessed by the Strengths and Difficulties Questionnaire. Mental health was examined as a potential mediator between childhood maltreatment and sleep characteristics. Adolescents exposed to childhood maltreatment had longer sleep onset latency (1:15 h vs. 47 min, $p < 0.001$), longer wake after sleep onset (34 min vs. 15 min, $p < 0.003$), lower sleep efficiency in weekdays (77.8%, vs. 85%, $p < 0.007$), and lower sleep efficiency in weekends (81.8% vs. 88.9%, $p < 0.001$) than the reference group. Mental health problems fully mediated the association between childhood maltreatment exposure and longer sleep onset latency and wake after sleep onset. The rate of insomnia did not significantly differ between the groups. This study suggests that older adolescents exposed to childhood maltreatment have more sleep problems than the general adolescent population, and that these problems may be explained by co-existing mental health problems. These findings highlight the potential utility of assessing and providing sleep-focused treatment to adolescents with a history of childhood maltreatment and mental health problems.

Key words: Childhood maltreatment, insomnia, adolescence, matched-control, sleep, mental health.

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INTRODUCTION

Childhood maltreatment (CM) is a health concern worldwide (Gilbert, Widom, Browne *et al*., 2009; Stoltenborgh, Bakermans-Kranenburg, Alink & van IJzendoorn, 2015) and is defined by the World Health Organization to include all types of physical and/or emotional ill-treatment, sexual abuse and neglect which occur in the context of a relationship of responsibility, trust or power (Schønning, Dovran, Hysing *et al*., 2021; The World Health Organization, 2020). Exposure to CM is associated with negative health outcomes in adolescence such as mental health problems (Lansford, Dodge, Pettit *et al*., 2002), physical health problems (Shin & Miller, 2012) and reduced daily-life functioning (Kim & Cicchetti, 2010) as well as sleep problems (Brown, Rodriguez, Smith, Ricker & Williamson, 2022; Langevin, Kenny, Kern, Kingsland & Pennestri, 2022). From a psychobiological perspective, CM may be conceptualized as a developmental risk factor to a range of health-related risks with high public health impact (Agorastos, 2017).

Adolescence is a period of significant biological, psychological, and social change, and sleep is no exception. During adolescence, sleep patterns and habits undergo major changes, which may lead to both insufficient or poor quality sleep (Carskadon, 2011).

These sleep characteristics may be even more pronounced among adolescents with experiences of CM. However, most of the current research on CM and sleep problems has been carried out on adult samples to examine the association between retrospective reports of CM and adult sleep problems, and considerably fewer studies have focused on CM and sleep problems among adolescents (Turner, Menzies, Fortier *et al*., 2020).

The current literature on CM and sleep in adolescence have produced somewhat inconsistent results, with some studies showing limited association between CM and sleep problems (Schneiderman, Ji, Susman & Negriff, 2018; Wamser-Nanney & Chesher, 2018). A longitudinal study on adolescents with CM history recruited from child welfare cases compared with a general population sample did not find an association between CM and sleep disturbances, measured by the Pittsburgh Sleep Quality Index (Schneiderman *et al*., 2018). The authors proposed that this might be due to the fact that both adolescents with CM history and the comparison youth lived in low-income urban areas, which might negatively impact sleep (Schneiderman *et al*., 2018). Another cross-sectional study on 260 children and adolescents seeking treatment at a child advocacy center found that sexual and emotional abuse were not associated with sleep

difficulties measured by the Child behavior checklist (Wamser-Nanney & Chesher, 2018). However, a cross-sectional study on Canadian adolescents aged 14 to 17 years found an increased risk of longer sleep onset latency (SOL) and found that CM was associated with shorter sleep duration on weekdays and weekends (Turner *et al.*, 2020). Shorter sleep duration in adolescents exposed to CM was also supported by findings in a recent systematic review and meta-analysis (Schønning, Sivertsen, Hysing, Dovran & Askeland, 2022). The meta-analysis on sleep duration in children and adolescents exposed to CM included five studies and found that they slept 12.1 min shorter (95% CI: 19.4–4.7, $p < 0.003$) than the controls (Schønning *et al.*, 2022). Another recent systematic review on sexual abuse and sleep in children and adolescents identified some gaps in the literature, and recommended that future studies on CM and sleep should include clear and specific definitions of sleep health dimensions, such as sleep satisfaction, duration or efficiency, and the use of multi-modal, multi-informant approaches to the measure of CM (Langevin *et al.*, 2022). In total, there are few studies on sleep health dimensions in adolescents with CM experiences, and particularly few studies comparing specific sleep characteristics in high-risk adolescents with the general population.

In addition to changes in sleep patterns and sleep quantity, CM in adolescence has also been linked to increased rates of self-reported sleep problems, including insomnia symptoms (Schønning *et al.*, 2022). Insomnia can be defined as lack of sleep quantity or quality caused by problems initiating or maintaining sleep despite adequate opportunities for satisfactory sleep (Sateia, 2014). Insomnia is common in adolescents, ranging from 4% to 24% depending on the diagnostic criteria used (Hysing, Pallesen, Stormark, Lundervold & Sivertsen, 2013; Johnson, Roth, Schultz & Breslau, 2006). The only meta-analysis on the association between insomnia symptoms and CM in adolescents found a fourfold higher risk of insomnia symptoms among children and adolescents with CM experiences compared to similar samples from the general population (Schønning *et al.*, 2022). Overall, most studies support the link between CM exposure and sleep problems in adolescence, but more detailed investigation using well-established sleep measures of this association are still needed (Schønning *et al.*, 2022).

Mental health problems are common in adolescents exposed to CM, and they tend to co-occur with sleep problems in adolescence (Short, Bartel & Carskadon, 2019). A recent cross-sectional study on foster youth examined the role of general mental health problems in explaining how traumatic events may affect difficulties initiating and maintaining sleep (Lehmann, Gärtner Askeland & Hysing, 2021). They found that the association between traumatic events and sleep problems were partly mediated by mental health problems, and that this confirms the important role of mental health problems on sleep in adolescence (Lehmann *et al.*, 2021). These findings highlight the importance of considering mental health problems when examining sleep in adolescents with CM experiences and should be investigated further.

The aim of the current study is to fill some of the aforementioned research gaps. The study will compare a sample with confirmed CM experiences to a matched-control sample from the general population to provide a more in-depth understanding of the association between CM and sleep patterns. Furthermore, our understanding of the sleep of adolescents exposed to CM will be expanded by adopting a multi-modal and multi-informant approach for the CM assessment, as well as for the measurement of several specific sleep parameters.

Based on these considerations, the aim of the current study was to examine sleep patterns and sleep problems in a sample of Norwegian 16–19-year-old adolescents with CM experiences and compare them to an age- and sex matched sample of adolescents from the general population. A secondary aim of the study was to investigate if mental health problems mediated the association between CM and sleep.

METHODS

Procedure and sample

The sample in the current study comes from the Norwegian Triple-S Cohort study (Triple-S), which has been described in detail elsewhere (Schønning *et al.*, 2021). All participants from the Triple-S sample attended the Stine Sofie Centre (SSC) for a week-long stay and were invited to participate in the study at the start of their attendance. The SSC is a centre for children, adolescents and their families that focus on coping and mastery after exposure to CM. All children or adolescents who have been subjected to CM are eligible for a stay at the SSC and for inclusion in the current study (Schønning *et al.*, 2021). A stay at the SSC provides a safe environment that focuses on helping children and adolescents recover from CM victimization. The activities at the SSC aim to improve their resilience to stress, with learning- and coping-focused activities led by health personnel at the center (Kolb, Dovran, Fernee & Bøe, 2022).

To be included in the current study, participants had to be between 16 and 19 years old, have been exposed to at least one form of CM that was substantiated by health personnel, child protective services, crisis centres or other official instances, and be able to complete the questionnaire in the Norwegian language. Self-reported data, completed on tablets, was collected during their stay at the SSC, from January 2021 to February 2022. In all, 53 adolescents attended the SSC in this period, of whom 42 adolescents consented to participate, yielding a participation rate of 79.2%. We also invited former participants, who attended the SSC between 2016 and 2021, to participate in the study. We attempted to recruit adolescents both via the SSC's website and social media platforms, as well as more directly via e-mails and telephone calls. Adolescents who agreed to participate were sent a unique link to the online questionnaire with the consent form and completed the survey at home. Twenty additional adolescents were recruited during this phase, yielding an overall sample size of 62 adolescents. However, due to uncertainties related to how many adolescents had changed contact information, or had moved since their SSC stay, we were unable to provide an estimated participation rate for this recruitment phase.

The reference group

The reference group consisted of adolescents from the youth@hordaland study (y@h). Y@h invited all adolescents aged 16 to 19 years in Hordaland county. Participants received an email with information, followed by an SMS reminder. The schools allocated time during school hours to complete the questionnaire. For those not in school, they received information by post. Project staff were available by phone for questions. The y@h sample included 10,257 participants, out of 19,439 eligible adolescents (53% participation rate) and was conducted in 2012.

For each of the 62 included participants from the Triple-S study, we randomly selected four adolescents from the y@h population as a reference group. The two samples were matched on sex and age, in order

to improve precision of the analyses and control for the matching factors (Pearce, 2016). A ratio of four controls per case has been suggested as sufficient, as increasing the number of controls beyond this does not yield any notable power improvements (Grimes & Schulz, 2005). To achieve a ratio of 4:1, we expanded the age range in the matching process to ±1.5 years. This led to inclusion of 238 participants from the y@h population.

Measures

Age and sex were retrieved from each participants' Norwegian 11-digit personal identity number. The first six numbers are the date of birth, and the 9th digit identifies sex at birth based on it being an odd or even number. School affiliation was assessed through a single item where the participants were asked to choose the response that best described their daily life. They were provided with three responses: "enrolled in school," "apprentice" or "not in school."

Maltreatment measures

In the Triple-S sample, all participants had experienced at least one form of CM during their lifetime. CM assessment was only carried out in the Triple-S sample. We assessed five categories of CM: *physical abuse, sexual abuse, psychological abuse, neglect and witnessing intimate partner violence* (IPV). Several of the CM measures are based on validated scales (e.g. the Juvenile Victimization Questionnaire, Finkelhor, Hamby, Ormrod & Turner, 2005; and the Conflict Tactics Scale, Straus, 1995), while others have been added to provide further specificity to the assessment of CM exposure, and has been culturally adapted and previously used in studies on CM in Norway, such as the UEVO-study by Hafstad, Sætren, Myhre, Bergerud-Wichstrøm and Augusti (2020). CM history was assessed with a multi-modal, multi-informant approach, which is often considered the "gold standard" within the research field (Hardt & Rutter, 2004) and has been recommended in recent systematic reviews (Langevin *et al.*, 2022). The polyvictimization variable was created by summarizing the number of CM forms each participant had experienced.

Physical abuse and *sexual abuse*. These were assessed using questions developed by Jernbro and Janson (2017) based on the Conflict Tactics Scale (Straus, 1995) and questions from the ACE-study (Anda, Butchart, Felitti & Brown, 2010). Physical abuse was assessed with questions covering various degrees of physical violence carried out by a caregiver at home. We dichotomized physical abuse into a moderate and a severe category, with three questions assessing each category. Moderate physical abuse includes having been pinched, pushed violently, or struck with an open hand. Severe physical abuse includes having been hit with fists, kicked, or beaten up. Respondents replied "yes" or "no" and were scored as a case if they confirmed having experienced at least one incident of physical abuse.

Sexual abuse. This was assessed by six questions covering various degrees of sexual abuse from adults, and the same six questions about sexual abuse from peers. We dichotomized sexual abuse into contact abuse, assessed by three questions such as "has an adult touched your private parts" or "had sex with you," and without contact abuse, assessed by three questions such as "has an adult ever made you show your private parts." Response categories ranged from "never" to "many times" on a four-point Likert scale. For the current study, responses <1 were used as a cutoff for dichotomizing.

Psychological abuse. This was assessed by eight questions from a module in the Juvenile Victimization Questionnaire (Finkelhor *et al.*, 2005). The questions covered various potentially abusive experiences from caregivers at home, such as being told they are not wanted, unloved, threatened with violence, locked in confined spaces, or being mocked or yelled at. Response categories ranged from "never" to "very often" on a four-point Likert scale. "Sometimes" or more were used as a cutoff for dichotomizing having experienced psychological abuse.

Neglect. Neglect was assessed with six questions from a Juvenile Victimization Questionnaire module. These questions covered various experiences such as being adequately fed, having clean clothes, feeling loved or having caregivers incapacitated by drug or alcohol use. Response categories were presented on a four-point Likert scale and ranged from "never" to "very often/always" and if the adolescent responded "sometimes" or more frequent to any of the questions they were scored as having experienced neglect.

IPV. IPV was measured with six questions about witnessing one of their caregivers being psychologically or physically abused. Psychological abuse were assessed using two questions asking if they have witnessed one of their caregivers being frequently scolded or ridiculed, and physical abuse was assessed with four questions of varying forms of violence, from being pushed violently to being beat up. Responses were categorized on a four-point Likert scale from "never" to "often" and participants were registered as having been witness to IPV if they responded "often" or "a couple of times."

Sleep measures

Sleep measures used in the Triple-S study were identical to the sleep measures used in y@h (Hysing *et al.*, 2013). Participants reported bedtime and rise time separately for weekdays and weekends. Wake after sleep onset (WASO) and SOL were reported for weekends and weekdays jointly. The time in bed variable was calculated as the difference between bedtime and rise time, while sleep duration was calculated by subtracting SOL and WASO from time in bed. To obtain sleep efficiency (SE), we divided sleep duration by time in bed and multiplied it by 100 to get the estimate in percentages.

Insomnia was operationalized in alignment with the diagnostic criteria from *Diagnostic and statistical manual of mental disorders 5* (DSM-5), similar to what has been done in previous studies of sleep in the y@h population (American Psychiatric Association, 2013; Hysing *et al.*, 2013). To meet the criteria for insomnia, participants had to: (1) report difficulties initiating or maintaining sleep at least 3 days per week; (2), report sleepiness or tiredness at least 3 days per week; and (3) their problems must have lasted more than 3 months (American Psychiatric Association, 2013).

Mental health

Mental health problems were assessed by the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 2001). SDQ is a short questionnaire with 25 items allocated into five different subscales scored on a three-point Likert scale. SDQ is considered a reliable assessment tool for mental health problems in general adolescent populations (Goodman, 2001). A study of the psychometric properties of SDQ in foster children supports the use of the SDQ total difficulties score when measuring mental health problems in high-risk populations (Lehmann, Heiervang, Havik & Havik, 2014). The total difficulties score consists of the four following subscales: conduct problems, emotional symptoms, peer problems and hyperactivity-inattention, giving a total score from 0 to 40 (Goodman, 2001). For the purpose of the current study, we used the SDQ total difficulties score as a measure of mental health problems.

Statistical analyses

IBM SPSS version 28 (IBM Corp, 2021) for Windows was used for all analyses. We conducted descriptive analyses to present the sample, with means, standard deviations, and frequencies. To compare mean scores between the two samples, we used independent samples *t* tests. As we assumed unequal variances between the samples, we used a Welch's *t* test (Delacre, Lakens & Leys, 2017). As a standardized effect size, we used Cohen's *d* to report mean differences between the samples. We used the standard interpretation of Cohen's *d* effect sizes (0.20 = small, 0.50 = moderate, and ≥0.80 = large) (Cohen, 2013). To adjust for mental health problems, we used a univariate general linear model and report estimated marginal means. There was generally very little missing data

(<4%) on the included variables, and the missing values were handled using listwise deletion. The mediation analysis was conducted using the PROCESS macro by Hayes in SPSS (Hayes, 2017). The confidence intervals (CI) for the indirect effect were BCa-bootstrapped CI based on 1,000 samples.

Ethics

The Triple-S study has been approved be the Regional Committee for Ethics in Medical and Health Research in the south-eastern region of Norway (#95445). In Norway, adolescents are allowed to independently consent to participate in all research from 16 years of age, and from 12 years of age on sensitive subjects such as CM (LOVDATA, 2017). All participants from the Triple-S sample provided an electronic consent to participate in the study. Participants have been informed about their possibility to withdraw from the study at any point, and with no consequences for their future contact or help from the SSC (Schønning *et al.*, 2021).

All adolescents participating in y@h have provided electronic consent for participation. Y@h has been approved by the Regional Committee for Medical Research Ethics in Western Norway (#2011/811) and the National Data Inspectorate.

RESULTS

Participants

The mean age of the Triple-S sample was 17.9 years (*SD* = 1.3), and 17.7 years (*SD* = 0.9) for the Y@H sample. Both samples had 87% female participants. In the Triple-S sample, 73.3% were in school, 10% were apprentices and 16.7% were not in school. In the y@h sample, 96.3% of the sample were in school, 1.8% were apprentices and 1.8% were not in school.

Maltreatment exposure in the Triple-S sample

All 62 participants in the Triple-S sample had been exposed to at least one form of maltreatment. The most common forms of maltreatment were *psychological abuse* (83.9%), *neglect* (74.2%), and *moderate physical abuse* (59.7%). We found the following distribution of polyvictimization in the Triple-S sample: 7.1% of the sample had been exposed to one form of maltreatment, 14.3% to two forms, 17.9% to three forms, 33.9% to four forms and 26.8% to five forms of maltreatment. See Table 1 for the detailed maltreatment exposures in the Triple-S sample.

Sleep characteristics

Table 2 shows sleep characteristics in the two samples separately for weekdays and weekends. On weekdays, adolescents with CM experiences had significantly earlier bedtimes (22:59 vs. 23:25) and later rise times (07:33 vs. 06:50) compared to the reference group. Adolescents from the Triple-S sample spent significantly longer in bed on weekdays, with 8:33 h (*SD* 1:38) compared to 7:25 h (*SD* 1:05) for the matched y@h sample, which was significantly shorter (*d* = 0.88). Adolescents with CM history had a significantly lower SE during weekdays 77.8% (*SD* 17.1%) compared to the reference group which had a SE of 85% (*SD* 18.3%).

Regarding sleep characteristics on weekends, adolescents with CM experiences had a bedtime of 00:31 (*SD* 1:31) compared to

Table 1. *Maltreatment exposure in the Triple-S sample*

	Triple-S sample		
Type of maltreatment	Girls (*N* = 54)	Boys (*N* = 8)	Total (*N* = 62)
Moderate physical abuse, *n* (%)	31 (57.4)	6 (75.0)	37 (59.7)
Severe physical abuse, *n* (%)	18 (34.0)	2 (28.6)	20 (33.3)
Sexual assault without contact by an adult, *n* (%)	24 (47.1)	1 (12.5)	25 (42.4)
Sexual assault with contact by an adult, *n* (%)	29 (55.8)	1 (12.5)	30 (50.0)
Sexual violations by peers, *n* (%)	32 (59.3)	0 (0.0)	32 (51.6)
Sexual assaults by peers, *n* (%)	28 (52.8)	0 (0.0)	28 (45.9)
Psychological abuse, *n* (%)	44 (81.5)	8 (100)	52 (83.9)
Witness to psychological abuse (mother), *n* (%)	28 (51.9)	5 (62.5)	33 (53.2)
Witness to physical abuse (mother), *n* (%)	17 (32.1)	3 (37.5)	20 (32.8)
Witness to psychological abuse (father), *n* (%)	4 (7.5)	1 (14.3)	5 (8.3)
Witness to physical abuse (father), *n* (%)	2 (3.8)	0 (0.0)	2 (3.3)
Neglect, *n* (%)	39 (72.2)	7 (87.5)	46 (74.2)

Note: N = number of participants.

Table 2. *Sleep characteristics in the Triple-S and matched y@h sample*

	Triple-S (*N* = 62) Mean (*SD*)	Y@H (*N* = 238) Mean (*SD*)	*p* value	Cohen's *d*
Weekdays				
Bedtime	22:59 (1:29)	23:25 (1:07)	0.016	−0.56
Rise time	07:33 (1:30)	06:50 (0:52)	<0.001	0.84
Time in bed	08:33 (1:38)	07:25 (1:05)	<0.001	0.88
Sleep duration	06:43 (2:03)	06:22 (1:46)	0.198	0.12
Sleep efficiency (%)	77.8 (17.1)	85.0 (18.3)	0.007	−0.41
Weekends				
Bedtime	00:31 (1:31)	01:32 (1:32)	<0.001	−0.77
Rise time	10:27 (1:25)	11:11 (1:32)	<0.001	−0.65
Time in bed	09:55 (1:15)	09:39 (1:25)	0.172	0.13
Sleep duration	08:09 (1:53)	08:36 (1:53)	0.096	−0.18
Sleep efficiency (%)	81.8 (15.5)	88.9 (13.2)	<0.001	−0.49
Weekdays/weekends				
Sleep onset latency	1:15 (0:55)	0:47 (0:54)	<0.001	1.25
Wake after sleep onset	0:34 (0:46)	0:15 (0:33)	0.003	0.47
Subjective sleep need	8:46 (1:49)	8:44 (1:53)	0.927	0.01

Note: N = number of participants; SD = standard deviation.

the reference group's bedtime of 01:32 (*SD* 1:32). The adolescents with CM history had an earlier rise time of 10:27 (*SD* 1:25), whereas the reference group had a rise time of 11:11 (*SD* 1:32). The adolescents with CM history had a SE of 81.8% (*SD* 15.5%) and the reference group had a SE of 88.9% (*SD* 13.2%). Differences in sleep duration during weekends were not statistically significant, but there was still a mean difference of 27 min between the samples.
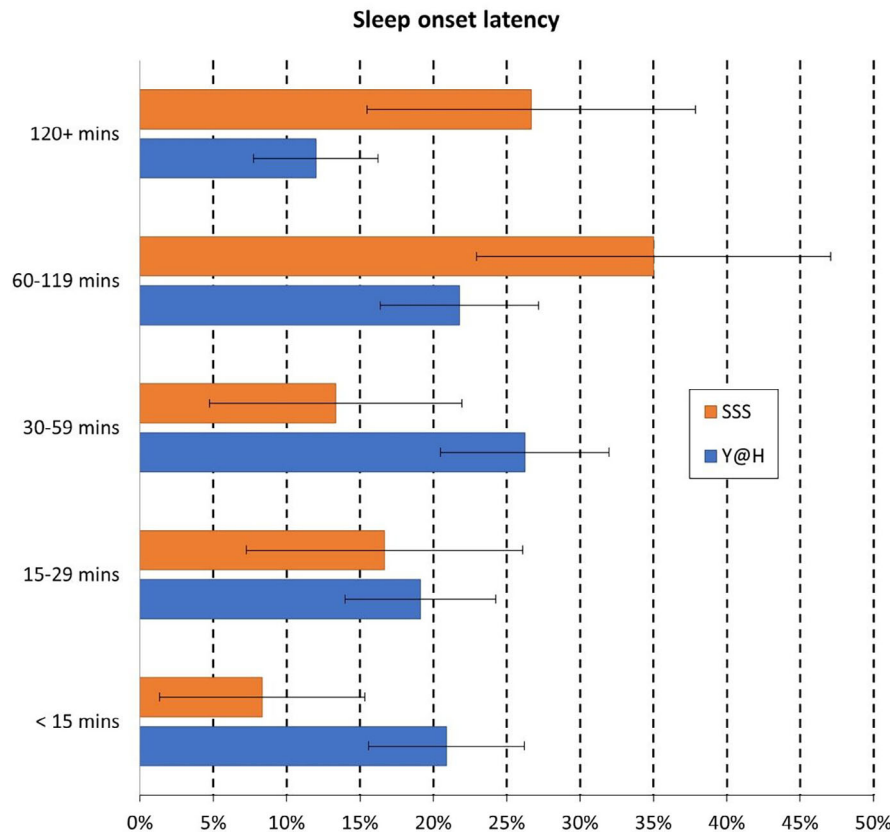
Fig. 1. SOL distribution in categories for the Triple-S and y@h sample. Mins, minutes; Y@H, youth@hordaland.

SOL and WASO

The Triple-S sample had a significantly longer mean SOL of 1:15 h (*SD* 0:55), which was on average 28 min longer than the reference group's SOL of 0:47 h (*SD* 0:54). Figure 1 shows a detailed SOL distribution for the two samples. In total, 61.7% of the Triple-S sample reported a SOL of 60 min or more, compared to 33.8% in the y@h sample.

Regarding WASO, the Triple-S sample spent an average of 34 min (*SD* 0:46) awake during the night, significantly longer than the reference group's average of 15 min (*SD* 0:33). See Fig. 2 for WASO distribution within both samples.

Insomnia

The proportion who reported insomnia was 35% (*n* = 21) in the Triple-S sample and 24% (*n* = 54) in the reference group (df = 283, *p* = 0.086). We analyzed the association between polyvictimization and insomnia in the Triple-S sample, and the association was not statistically significant.

Mediation analyses

Mediation analyses were conducted in the Triple-S sample for SOL and WASO, with CM as the independent factor and mental health problems as a potential mediator. Both mediation analyses were significant (p =< 0.001). Our findings also show that the direct effects from CM to SOL (p = 0.425) or WASO (p = 0.776)

were insignificant, suggesting a full mediation by mental health problems. See Fig. 3 for details.

DISCUSSION

The aim of this study was to examine the sleep characteristics of a sample of adolescents exposed to CM compared to an age- and sex-matched reference group from the general population. Our findings show that adolescents who had experienced CM had lower SE, longer SOL and longer WASO than an age- and sex-matched reference group of adolescents from the general population. The longer SOL and WASO were fully mediated by mental health problems.

Adolescents with maltreatment experiences had a considerably longer SOL than the reference group, with a mean SOL of 1:15 h compared to 47 min. The SOL of both samples fall within the category of long SOL, which is often considered to be over 30 min, a threshold that indicates clinically meaningful differences (Gradisar, Gardner & Dohnt, 2011). Our results also showed a longer mean WASO for the adolescents who had experienced CM. SOL and WASO are parameters that are closely connected to SE, since longer SOL and WASO leads to a lower SE (Reed & Sacco, 2016). The adolescents with CM history had a SE of 78% in weekdays, compared to the reference group's 85% in weekdays. The clinical cutoff used for SE is normally 85%, and scoring <85% is considered having a low SE (Lacks & Morin, 1992). The adolescents with CM experiences scored
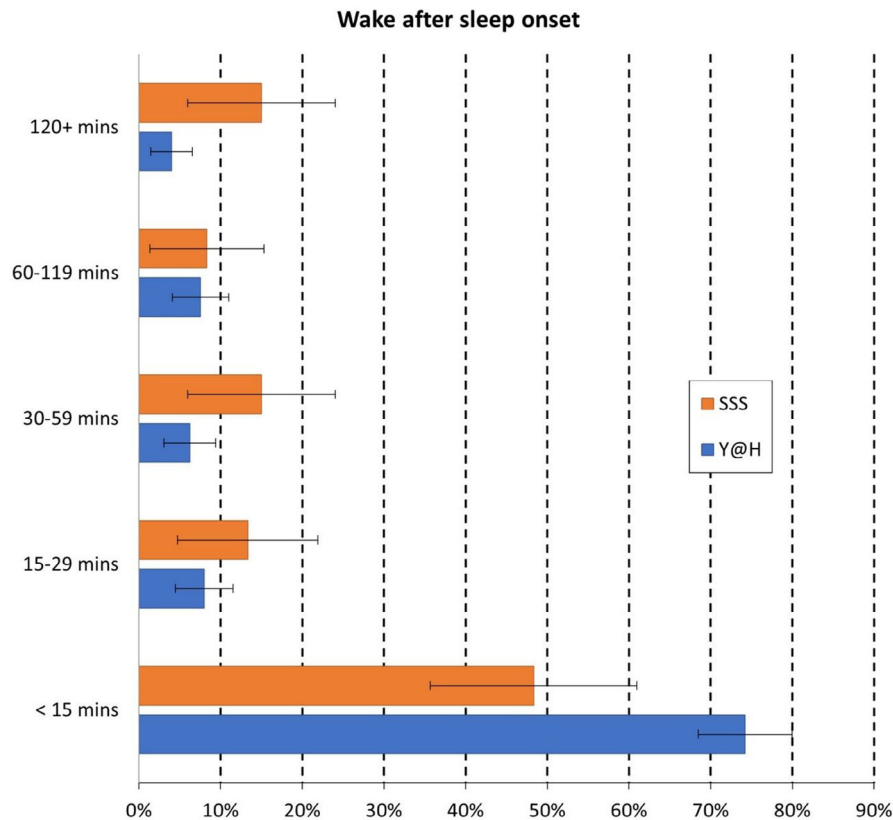
Wake after sleep onset

Fig. 2. WASO distribution for the Triple-S and y@h sample. Mins, minutes; Y@H, youth@hordaland.
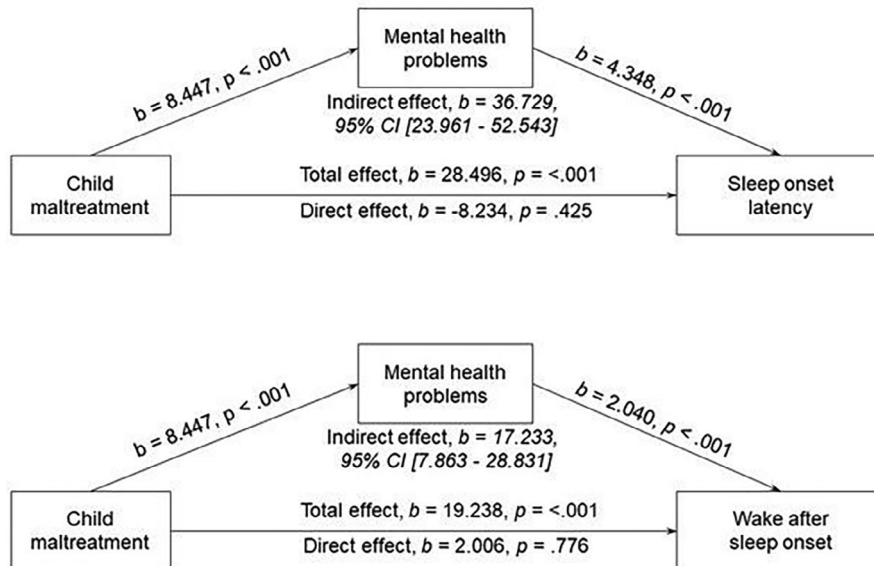

Fig. 3. Models of CM as predictor for SOL and WASO mediated by mental health problems. The CI for the indirect effects are BCa bootstrapped CI based on 1,000 samples.

below the clinical threshold for both weekdays and weekends, which is often considered an indication of sleep problems (Lacks & Morin, 1992). However, as WASO and SOL were assessed jointly for weekdays and weekends, our findings of different SE for weekdays and weekends should be interpreted with caution.

Longer SOL and WASO in adolescents with a maltreatment history compared to general population youth has been found in previous research, but the magnitude of the difference varies between studies (Langevin *et al.*, 2022; Schønning *et al.*, 2022; Turner *et al.*, 2020). A recent study on high-risk adolescents receiving child welfare services found the SOL to be 32 min longer than in their general population sample, which is similar to the 28 min mean difference in SOL we found in the current study (Almaas, Heradstveit, Askeland *et al.*, 2022). WASO was also

found to be similar in the mentioned study, compared to the Triple-S sample. The study population in the mentioned study is likely to have a history of CM, and is expected to have a similar risk profile as the Triple-S sample, which support the validity of the findings of the current study (Almaas *et al.*, 2022).

Adolescents with CM experiences reported time spent in bed on weekdays to be more than an hour longer than the y@h sample, which is closely connected to the longer SOL and WASO, and lower SE. There could be several mechanisms involved in their inability to sleep, and one such mechanism is cognitive hyperarousal. Cognitive hyperarousal can be described as a high level of arousal, and often includes pre-sleep rumination and emotional arousal, which can conflict with sleep onset (Fernández-Mendoza, Vela-Bueno, Vgontzas *et al.*, 2010; Schønning *et al.*, 2022). This has been suggested in a recent systematic review, and evidence of cognitive hyperarousal has been found in victims of CM, but rarely examined as a possible mechanism of how CM and sleep problems are related (Pfaff, Jud & Schlarb, 2021).

The role of cognitive hyperarousal in long SOL in the adolescents with CM history seems to fit well with our findings, as mental health problems fully mediated the association between CM and SOL. The SDQ total problems score we used as a measure of mental health problems included emotional symptoms, which covers anxiety and depressive symptoms, which could point to cognitive hyperarousal being a possible mechanism in understanding their sleep problems. Another possible mechanism could be poor sleep hygiene, as both samples report a considerably prolonged SOL. Other studies have highlighted the role of prebedtime media use in understanding prolonged SOL and poor sleep hygiene, and this could be a possible mechanism in the current study (Exelmans & Van den Bulck, 2017; Saxvig, Bjorvatn, Hysing *et al.*, 2021).

Adolescents with CM experiences had a longer WASO than the reference group, and a possible explanation for this could be nightmares, as adolescents with CM history are at a clearly increased risk for nightmares (Schønning *et al.*, 2022). Longer WASO and more frequent nighttime awakenings are also a hallmark of post-traumatic stress disorder (PTSD), and it is likely that a proportion of our sample meets PTSD-criteria which could help explain their impaired sleep (Spoormaker & Montgomery, 2008). The current study did not assess PTSD in the Triple-S sample, but measured general mental health problems, and these were found to fully mediate the association between CM exposure and WASO in our sample with confirmed CM experiences.

The adolescents with CM experiences reported adequate bed times, and sufficient time in bed to meet their subjective sleep need of 8:46 h, which is within experts' sleep time recommendations (Hirshkowitz *et al.*, 2015). However, they reported a sleep duration of 06:43 h during weekdays, which is 02:03 h shorter than their subjective sleep need, suggesting a considerable sleep deficit. Based on our results, the adolescents exposed to CM seem to have some of the sleep behavior that facilitates sleep, such as sufficient time in bed and reasonable bedtimes but have problems falling asleep and staying asleep through the night. Both researchers and health personnel should seek to identify the reasons for their inability to sleep, and the

mechanisms in which they work, and provide targeted healthcare in order to treat the sleep problem and improve their sleep.

Adolescents with a CM history also reported a considerably later rise time at weekdays. This finding differs somewhat from other studies, with a recent population-based study on high-risk adolescents receiving child welfare services reporting a considerably earlier rise time than the Triple-S sample (Almaas *et al.*, 2022). Another study on adolescent victims of rape also reported an earlier rise time than our Triple-S sample (Bicanic, Postma, Sinnema *et al.*, 2013). This finding could be explained by lower school attendance within the Triple-S sample, making it less important to get up early in the morning. In the Triple-S sample, 16.7% of the adolescents reported that they were not in school, compared to 1.8% in the y@h sample. Early school hours are likely to be a key motivator to rise early on weekdays for this age group. Other studies have also found that adolescents with maltreatment experiences have more frequent school absences (Slade & Wissow, 2007). However, we cannot determine the direction of causality in this case; they could be absent from school because of difficulties in getting up early enough in the morning, or they might not need to rise early as they are not enrolled in school. Exposure to CM has been linked to an increased risk of school difficulties and hardship at school, which are factors likely to increase school absence (Dovran, Winje, Arefjord *et al.*, 2019).

The proportion who reported insomnia in adolescents with CM history was 35%, compared to the reference group's 24%, but this finding was not significant. However, other studies have found an increased risk of insomnia among adolescents with maltreatment history (Brown *et al.*, 2022; Schønning *et al.*, 2022; Wang, Raffeld, Slopen, Hale & Dunn, 2016). A population study on Brazilian adolescents found an insomnia prevalence of 26.4% in a maltreated sample, compared to 10.9% in the non-maltreated comparison group (Fontes, Conceição & Machado, 2017). Even though the rates of insomnia were not significantly different in our two samples, an increased risk of insomnia in adolescents with CM has been established in other studies (Fontes *et al.*, 2017; Schønning *et al.*, 2022), and a reason for our non-significant findings could be that the study had too few participants with CM history to establish statistical differences (Cohen, 2013).

It should be noted that the adolescents exposed to CM were recruited approximately 10 years later than the reference group, which could potentially complicate the comparison between the two samples. However, a recent population-based study of Norwegian older adolescents showed that both the quality and quantity of sleep has remained relatively stable during the last decade, with only small or negligible differences between 2012 and 2021 on core sleep parameters (sleep duration, sleep efficiency, SOL, and WASO) (Saxvig *et al.*, 2021). These findings support the suitability of the y@h sample to be used as a reference group in the current study. The participants from the y@h sample had a school attendance of 98%, compared to 92% of the general population aged 16 to 18 years in 2012, which could limit generalizability (Hysing, Pallesen, Stormark *et al.*, 2015). Previous studies on former waves of the Bergen Child Study, which are the same participants as in the y@h sample, have found that non-participating children had more

emotional and behavioral problems compared with participants, suggesting that sleep problems could be underestimated in the y@h sample (Stormark, Heiervang, Heimann, Lundervold & Gillberg, 2008).

There was a high prevalence of polyvictimization in our sample of adolescents with a CM history. The level of polyvictimization was not surprising since the participants were recruited from a center for those who have been exposed to CM, and there is probably a threshold that must be reached in terms of exposure before anyone takes the initiative to visit such a center. The levels of polyvictimization in our sample is similar to findings in other studies, demonstrating that most children exposed to maltreatment have experienced more than one type of violence, and that the Triple-S sample is similar to other adolescents exposed to CM not attending the SSC (Turner, Finkelhor & Ormrod, 2010). In general, polyvictimization is associated with more severe health problems (Turner et al., 2010) but contrary to our expectations, being exposed to more forms of CM was not significantly associated with insomnia in the current study. Other studies have found a dose–response relationship between polyvictimization and risk for insomnia (Wang et al., 2016). Turner and colleagues also found a slight dose–response trend between polyvictimization and SOL and fewer hours slept on weekdays, which are relevant factors in a insomnia diagnosis (Schønning et al., 2022). One reason that poly-victimization was not associated with insomnia in the current study could be the lack of statistical power, as only 7.1% of the sample of 62 participants had not experienced poly-victimization. Creating different cut-offs and groups for poly-victimized participants could have influenced our findings.

Adolescence is a crucial developmental period and sleep problems could hinder a healthy development, particularly for high-risk populations such as those exposed to CM. Another important aspect to consider regarding sleep in this population is that the chronicity of insomnia is high in adolescents, and that the problems are likely to transition into adulthood (Johnson et al., 2006). Therefore, it is of particular importance that future studies continue to increase our knowledge on how CM affects sleep disturbances in adolescence, in order to improve early interventions and targeted service delivery for sleep problems in this high-risk population.

Strengths and limitations

There are several limitations to consider in the current study. First, the study included a relatively small sample size with a history of CM, yielding potential challenges caused by limited statistical power. Second, the study comprised an imbalanced sex distribution (only 13% of the Triple-S sample were boys), which may limit the generalizability of our findings to boys. Third, there may be some unmeasured confounders, such as socioeconomic status, which is likely to be associated with both sleep problems (Grandner, Patel, Gehrman et al., 2010) and CM (Imran, Cross & Das, 2019). Fourth, due to the cross-sectional design, we cannot determine the direction of the association between sleep and mental health or inform development over time (Olsen & St George, 2004). The mediation analysis should also be interpreted with caution as the cross-sectional design does not provide information about causality. Fifth, we did not assess PTSD or

nightmares in the adolescents with CM history, and both nightmares (Schønning et al., 2022) and PTSD (Cloitre et al., 2009) are common in this population, and are likely to cause both longer SOL and WASO. Finally, WASO and SOL were not assessed separately for weekdays and weekends. This may be problematic as SOL is likely to be shorter on weekends as adolescents are freer to delay their bedtime, which in turn could have affected the reported SE and sleep duration.

Strengths of the current study include the matched-control design, allowing for age and sex to be evenly distributed in the two samples, removing the possibly confounding effects of these factors (Pearce, 2016). Another important strength is the high participation rate in this vulnerable group of adolescents. As adolescents exposed to CM are typically very difficult to recruit in epidemiological studies, the Triple-S cohort study provides valuable data that are otherwise lacking from larger studies of the general population. Combined with the inclusion criteria for the Triple-S study, our findings may be regarded as representative for other adolescents with CM history. Another strength of the current study is the detailed assessment of sleep parameters. Although objective sleep measurements, such as actigraphy or polysomnography, is often regarded as the gold standard of sleep assessment, it is also impractical to use in many research settings. In fact, subjective sleep measurements are recommended for use in both clinical and population-based research and have been found to be valid and unbiased measures of sleep, especially among adolescents (Biddle, Robillard, Hermens, Hickie & Glozier, 2015; Zinkhan, Berger, Hense et al., 2014).

CONCLUSION

Overall, the findings of the current study suggest that adolescents exposed to CM have a higher risk of sleep problems compared to the general population. Furthermore, these sleep problems seemed to be closely related to mental health problems. Our findings highlight the importance of establishing routines for assessing mental health problems when sleep problems are presented in adolescents exposed to CM. This may involve providing children with access to mental health services, as well as to prevent CM and promote healthy sleep habits. Future studies should seek to examine and assess the mechanisms involved in how CM leads to sleep problems.

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