



BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

The relationship between emotional dysregulation and sleep in children and adolescents with ADHD: protocol for a systematic review

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2025-099096
Article Type:	Protocol
Date Submitted by the Author:	09-Jan-2025
Complete List of Authors:	Sørensen, Lin; University of Bergen, Department of Biological and Medical Psychology Jensen, Daniel; Betanien sykehus AS; Betanien Hospital Lykkebø, Amalie; University of Bergen, Department of Biological and Medical Psychology Adolfsson, Steinunn; University of Bergen, Department of Biological and Medical Psychology Holmen, Nina; The Norwegian ADHD Association Becker, Stephen; Cincinnati Children's Hospital Medical Center, Division of Behavioral Medicine and Clinical Psychology; University of Cincinnati College of Medicine, Department of Pediatrics Flo, Elisabeth; University of Bergen, Department of Clinical Psychology
Keywords:	Attention Deficit Disorder with Hyperactivity, SLEEP MEDICINE, MENTAL HEALTH

SCHOLARONE™
Manuscripts

The relationship between emotional dysregulation and sleep in children and adolescents with ADHD: protocol for a systematic review

Lin Sørensen¹, Daniel A. Jensen², Amalie Lykkebø¹, Steinunn Adolfsdottir¹, Nina Holmen³, Stephen P. Becker^{4,5}, & Elisabeth Flo-Groeneboom⁶

¹Department of Biological and Medical Psychology, University of Bergen, Bergen, Norway

²Betanien Hospital Bergen, Bergen, Norway

³The Norwegian ADHD Association, Oslo, Norway

⁴Division of Behavioral Medicine and Clinical Psychology, Center for ADHD, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA

⁵Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, OH, USA

⁶Department of Clinical Psychology, University of Bergen, Bergen, Norway

Corresponding to:

Professor Lin Sørensen; lin.sorensen@uib.no.

Word count of manuscript (excl. title page, abstract, and references): 1693

ABSTRACT

Introduction: Over half of children and adolescents with ADHD have difficulties with emotional dysregulation and/or sleep, yet the interrelations between emotional regulation and sleep are not well-characterized in this population. This systematic review will address the relationship between these difficulties and investigate whether specific aspects of emotional dysregulation (EDR) are more strongly related with sleep in youth with ADHD.

Methods: We will adhere to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guideline for systematic reviews. A wide set of electronic databases will be searched for peer-reviewed quantitative studies investigating the relationship between EDR and sleep in children and adolescents (ages 5 to 18 years) with ADHD. In addition, the reference list of all studies will be searched for other relevant studies and Scopus used to search for citations of the included studies. We will also contact experts in the field to call for published and unpublished studies. The primary outcome will be the effect of the relationship between EDR and sleep in children and adolescents with ADHD. We will look at EDR and sleep broadly and considering the multifaceted nature of both terms. Secondary outcomes will include which facets of EDR and sleep that have been measured and how they have been measured, developmental differences between children and adolescents with ADHD, and how and the extent to which studies controlled for use of CNS medications and comorbid disorders in their study design and/or statistical analyses. The quality and risk of bias of the included studies will be assessed using the Mixed Methods Appraisal Tool (MMAT).

Ethics and dissemination: This protocol is for a review of studies and does not involve any new data collection and does therefore not need an ethical approval. The results will be presented at international conferences and in a peer-reviewed journal.

PROSPERO registration number: CRD42024612984

Keywords: ADHD; emotion regulation; mood; sleep; circadian rhythms.

ARTICLE SUMMARY

Strengths and limitations of this study

- The study will be conducted by a team with expertise on ADHD, sleep, and emotional dysregulation in children and adolescents.
- We will consider the complexity of investigating the relation between sleep and emotional dysregulation in ADHD by taking into account the multifaceted nature of emotional dysregulation and sleep.
- The results from the study will be used for recommendations for future studies on how to best design studies on the relation between sleep and emotional dysregulation in ADHD.
- The protocol was designed, and the systematic review will be conducted, in collaboration with a user organization to embrace the perspectives of patients with ADHD.
- A limitation is that we will predominantly include peer-reviewed studies.

INTRODUCTION

Everyday challenges that children and adolescents with Attention-Deficit/Hyperactivity Disorder (ADHD) experience often extend beyond what can be explained by the core ADHD symptoms of inattention and hyperactivity/impulsivity^{1 2}. In particular, parents often report their children with ADHD to have either sleep problems³ or problems regulating strong emotions^{4 5}. Yet, there is still limited knowledge of how problems regulating strong emotions and sleep are related with each other despite suggestions that they both are causally related with ADHD⁶. It is thus clinically relevant and timely to conduct a systematic review on the relationship between emotional dysregulation (EDR) and sleep in ADHD to (1) understand the current evidence for an association, and (2) provide summative information that can guide future research and clinical work in this area.

EDR can be defined as when a child struggles significantly more than their peers with adaptively modifying their emotional state and responses according to the context they are in, to promote goal-oriented behavior^{4 5 7 8}. In ADHD, EDR is prevalent across the lifespan^{4 5} and is found to be genetically connected with ADHD^{9 10}. In ADHD, focus has often been on EDR of negatively valenced emotions and mood, although, also on struggles regulating sadness, worry, and expressions of positive emotions⁴.

Meta-analyses show that children³ and adolescents¹¹ with ADHD have problems with numerous aspects of sleep. Caregivers³ reports and adolescents' self-reports¹¹ show higher wakefulness compared with neurotypical controls leading to problems falling asleep, wakening during the nights, and early wakening in the mornings. The caregiver reports were supported by studies using objective measures of sleep such as polysomnography and actigraphy³. Additionally, children with ADHD

also more often had delayed sleep phase and sleep disordered breathing. Poorer sleep quality has been linked genetically with ADHD¹² and is reported consistently across the lifespan in ADHD¹³.

Both EDR and sleep problems may be causal traits of ADHD and not specifically related with each other as observed in neurotypical children and adolescents⁶. The complexity in understanding the relationship between EDR and sleep comprise also the often prescribed CNS medication and the high prevalence of comorbid disorders in ADHD¹³.

The aim is to conduct a systematic review of existing peer-reviewed studies to investigate if EDR and sleep are related in children and adolescents between 5 and 18 years old with ADHD. The primary research question is if EDR and poorer, insufficient, or misaligned sleep is co-dependent on each other beyond what can be explained by having an ADHD. Secondary research questions comprise i) whether *specific* aspects of EDR are more strongly related with *specific* sleep domains in children with ADHD, ii) whether the method for measuring EDR and/or sleep influence the effects of the relationship between sleep and EDR, iii) whether there are a developmental differences between children and adolescents with ADHD in the relationship between EDR and sleep , iv) whether studies have controlled for use of CNS medications-, and v) whether studies have controlled for comorbid psychiatric disorders in their study design and/statistical analyses. We will be looking at EDR and sleep broadly and consider the multifaceted nature of both terms. EDR can comprise negative and positive expressions of emotions and/or mood, the recognition of and response to emotional expressions, and the regulation process per se, such as the use of strategies for coping with difficult emotions^{4 5}. Sleep can comprise sleep

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Supérieur (ABES) .

duration, sleep quality, sleep timing, night wakings, daytime sleepiness, and circadian preferences¹⁴.

METHODS AND ANALYSIS

We will follow the guidelines as stated in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) in this proposed study.

The protocol for this proposed systematic review is pre-registered in PROSPERO. We plan to start the study on 1 February 2025 and to complete it by 31 December 2025.

Search

We will search a wide set of electronic databases, including PsychINFO, Medline, EMBASE, and Web of Science. For the specific syntax that will be used for each database, see online supplemental 1. In addition, the reference list of all studies will be searched for other relevant studies and Scopus used to search for citations of the included studies. The search will be conducted with the support of the library consultancy at the University of Bergen. Duplicates will be removed by following the methods described by Hair, MacLeod, Liao, & Sena (2021).

Selection criteria

Study design

We will include all types of studies that have investigated the relationship between EDR and sleep in ADHD or in a sample with high symptom load of ADHD symptoms. This includes randomized controlled trials (RCTs) of sleep and/or EDR, other types of intervention studies, experimental studies of for instance the effects of sleep

restriction on EDR, population-, community-, or clinical-based studies of the concurrent correlations between EDR and sleep, and longitudinal studies.

Participants

We will include children and adolescents between 5 and 18 years old that have ADHD or elevated ADHD symptoms, and neurotypical controls and/or children and adolescents with non/lower levels of ADHD symptoms when such comparison groups are included in the studies. In studies including a wider age range than our inclusion criteria, we will use a mean sample age ≥ 5 or ≤ 18 . We will define adolescence as starting at 10 years old in accordance with the World Health Organization’s definition (see <https://www.who.int/>) and define childhood as < 10 years old and adolescence as ≥ 10 years old.

Reporting method and language

Original publications published in peer-reviewed journals that are written in English or in a Scandinavian language will be included.

Outcomes

The primary outcome of the current systematic review is the effect of the relationship between EDR and sleep in children and adolescents with ADHD. Secondary outcomes are i) the outcome measure of EDR and sleep, ii) how EDR and sleep have been measured, iii) developmental differences between children and adolescents with ADHD, iv) how use of CNS medication - and v) comorbid disorders- have been controlled for in the study design and/or statistical analyses.

Data collection

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Supérieur (ABES).

We will include studies and extract data in a two-step process. First, two independent investigators will screen for titles and abstracts of the studies after the initial search. Second, two independent investigators will read the full texts of all potentially relevant studies and decide on the final list of studies to include in the systematic review. Any disagreement will be resolved by an independent “third” investigator. The data will be extracted on study characteristics, such as facets of EDR and sleep investigated, how EDR and sleep were measured, sample description (e.g., ADHD or ADHD symptoms), sample size, sample demographics (e.g., percentage of boys/girls, race/ethnicity, use of CNS medication, and comorbidities), study design, and how use of CNS medication and comorbid disorders have been controlled for in the study design/statistical analyses. Additionally, the data will be extracted on effect sizes reported in the studies, such as Cohen’s d and partial eta-squared (η^2_p). The reported effect sizes will be used for estimating the size of the association/effects between EDR and sleep quality. E.g., Cohen’s d of 0.2, 0.5, and 0.8 will be used as benchmarks for small, medium, and large effects, respectively, and partial eta-squared of 0.01, 0.06, and 0.14 as benchmarks for small, medium, and large effects, respectively¹⁵. We will systematically contact authors when needing to gather unpublished information/data.

Study quality and risk of bias assessment

We will assess the quality and risk of bias of the included studies by using the Mixed Methods Appraisal Tool (MMAT; see Hong et al., 2018). This assessment will be done in connection with the data extraction, and will be assessed by at least two independent investigators, with disagreement resolved by a “third” independent investigator. Four of the authors (LS, DAJ, SA, and EFG) will train beforehand to calibrate the assessment of quality and risk of bias with the MMAT.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Patient and public involvement

Ms. Nina Holmen is the user and public involvement co-author to embrace the perspectives of patients with ADHD in the design of this protocol and further, in the data extraction and interpretations of results when conducting the systematic review.

ETHICS AND DISSEMINATION

Ethics

This is a protocol of an aggregated summary of existing studies, and will as such, not involve any new human subject's data collection and not need an ethical approval.

Dissemination

The procedures for data inclusion and extraction will be described to ensure transparency and replicability. The results of the systematic review will be disseminated in an internationally peer-reviewed journal, in addition to at national (e.g., organized by the Norwegian ADHD Association, the Norwegian ADHD Research Network) and international conferences (e.g., ADHD World Congress, Annual Meeting of the European Society for Child and Adolescent Psychiatry Congress).

Author Contributions LS designed the study and developed and wrote this protocol and the planned search strategies. EF-G co-designed the study and contributed together with DAJ and SA in developing and writing the protocol and plan for search strategies. AL was involved in the design of the study and piloting of search

Enseignement Supérieur (ABES) .
Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

strategies and data extraction. SPB and NH was involved in developing and writing this protocol.

Funding The University of Bergen and the L. Meltzer Høyskolefond is funding this project and publication fees. Stephen Becker is supported in part by grants from the National Institute of Mental Health (NIMH; R01MH122415), the Institute of Education Sciences, U.S. Department of Education (IES; R305A200028, R324A240155, R305A240106), and the Cincinnati Children's Research Foundation (CCRF). The content is solely the responsibility of the authors and does not necessarily represent the official views of the University of Bergen, IES, NIH, or CCRF.

Competing interests Lin Sørensen receives editorial honoraria as Associate Editor of Journal of the International Neuropsychological Society (JINS) and received a small research funding for speaking and conference support from Medice in 2023. In the past year, Stephen Becker discloses grant funding from the Institute of Education Sciences (IES), U.S. Department of Education; National Institute of Mental Health (NIMH); and Cincinnati Children's Research Foundation (CCRF), and has received book honoraria from Guilford Press, editorial honoraria as Joint Editor of *JCPP Advances*, grant review panel honoraria from the IES, and educational seminar speaking fees and continuing education course royalties from PESI® and J&K Seminars.

Patient consent for publication Not required.

Open access

REFERENCES

1. Faraone SV, Bellgrove MA, Brikell I, et al. Attention-deficit/hyperactivity disorder. *Nat Rev Dis Primers* 2024;10(1):11. doi: 10.1038/s41572-024-00495-0 [published Online First: 2024/02/23]

2. Klein RG, Mannuzza S, Olazagasti MA, et al. Clinical and functional outcome of childhood attention-deficit/hyperactivity disorder 33 years later. *Arch Gen Psychiatry* 2012;69(12):1295-303. doi: 10.1001/archgenpsychiatry.2012.271 [published Online First: 2012/10/17]
3. Cortese S, Faraone SV, Konofal E, et al. Sleep in children with attention-deficit/hyperactivity disorder: meta-analysis of subjective and objective studies. *J Am Acad Child Adolesc Psychiatry* 2009;48(9):894-908. doi: 10.1097/CHI.0b013e3181ac09c9 [published Online First: 2009/07/25]
4. Faraone SV, Rostain AL, Blader J, et al. Practitioner Review: Emotional dysregulation in attention-deficit/hyperactivity disorder - implications for clinical recognition and intervention. *J Child Psychol Psychiatry* 2019;60(2):133-50. doi: 10.1111/jcpp.12899 [published Online First: 2018/04/07]
5. Shaw P, Stringaris A, Nigg J, et al. Emotion dysregulation in attention deficit hyperactivity disorder. *Am J Psychiatry* 2014;171(3):276-93. doi: 10.1176/appi.ajp.2013.13070966 [published Online First: 2014/02/01]
6. Sonuga-Barke EJS, Becker SP, Bolte S, et al. Annual Research Review: Perspectives on progress in ADHD science - from characterization to cause. *J Child Psychol Psychiatry* 2023;64(4):506-32. doi: 10.1111/jcpp.13696 [published Online First: 2022/10/12]
7. Gross JJ. Emotion regulation: affective, cognitive, and social consequences. *Psychophysiology* 2002;39(3):281-91. doi: 10.1017/s0048577201393198 [published Online First: 2002/09/06]
8. Sheppes G, Suri G, Gross JJ. Emotion regulation and psychopathology. *Annu Rev Clin Psychol* 2015;11:379-405. doi: 10.1146/annurev-clinpsy-032814-112739 [published Online First: 2015/01/13]
9. Astenvald R, Frick MA, Neufeld J, et al. Emotion dysregulation in ADHD and other neurodevelopmental conditions: a co-twin control study. *Child Adolesc Psychiatry Ment Health* 2022;16(1):92. doi: 10.1186/s13034-022-00528-0 [published Online First: 2022/11/30]
10. Riglin L, Eyre O, Cooper M, et al. Investigating the genetic underpinnings of early-life irritability. *Transl Psychiatry* 2017;7(9):e1241. doi: 10.1038/tp.2017.212 [published Online First: 2017/09/28]
11. Marten F, Keuppens L, Baeyens D, et al. Sleep parameters and problems in adolescents with and without ADHD: A systematic review and meta-analysis. *JCPP Adv* 2023;3(3):e12151. doi: 10.1002/jcv2.12151 [published Online First: 2023/09/18]
12. Gregory AM, Agnew-Blais JC, Matthews T, et al. ADHD and Sleep Quality: Longitudinal Analyses From Childhood to Early Adulthood in a Twin Cohort. *J Clin Child Adolesc Psychol* 2017;46(2):284-94. doi: 10.1080/15374416.2016.1183499 [published Online First: 2016/08/04]
13. Becker SP. ADHD and sleep: recent advances and future directions. *Curr Opin Psychol* 2020;34:50-56. doi: 10.1016/j.copsyc.2019.09.006 [published Online First: 2019/10/20]
14. Gregory AM, Sadeh A. Annual Research Review: Sleep problems in childhood psychiatric disorders--a review of the latest science. *J Child Psychol Psychiatry* 2016;57(3):296-317. doi: 10.1111/jcpp.12469 [published Online First: 2015/09/29]
15. Cohen J. Statistical power analysis for the behavioral sciences. Hillsdale, NJ: Lawrence Erlbaum 1988.

APA PsycInfo (Ovid)

- 1 attention deficit disorder/ or attention deficit disorder with hyperactivity/
- 2 hyperactivity/
- 3 ("ADHD" or "ADDH" or "attention deficit" or "hyperkinetic").ti,ab,id.
- 4 1 or 2 or 3
- 5 exp sleep wake disorders/
- 6 exp sleep/
- 7 ("Sleep*" or "nocturnal" or "circadian" or "chronotype" or "insomnia" or "parasomnia" or
- 8 "dyssomnia").ti,ab,id.
- 9 5 or 6 or 7
- 10 emotional regulation/ or exp emotional control/ or emotional processing/ or exp self-control/
- 11 or self-regulation/ or socioemotional functioning/ or irritability/
- 12 (((emotion* or affect or mood) adj4 (regulation or dysregulation or control* or social* or
- 13 symptom* or awareness or stability or instability or labil* or impulsiv*)) or irritab*).ti,ab,id.
- 14 9 or 10
- 15 4 and 8 and 11

Comments to OVID databases:

/ indicates that the search term is a subject heading

.ti,ab,id. Search term in title, abstract, or key concepts

kf. Search term in author keywords

Adj proximity operator indicates that search terms are close to each other. Adj2 means that search term two is the first or second (2) word after search term one, or vice versa

Ovid MEDLINE(R) and In-Process, In-Data-Review & Other Non-Indexed Citations and Daily

- 1 attention deficit disorder with hyperactivity/
- 2 ("ADHD" or "ADDH" or "attention deficit" or "hyperkinetic").ti,ab,kf.
- 3 1 or 2
- 4 exp sleep wake disorders/
- 5 exp sleep/
- 6 ("Sleep*" or "nocturnal" or "circadian" or "chronotype" or "insomnia" or "parasomnia" or
- 7 "dyssomnia").ti,ab,kf.
- 8 4 or 5 or 6
- 9 self-control/ or emotional regulation/ or Irritable Mood/
- 10 (((emotion* or affect or mood) adj4 (regulation or dysregulation or control* or social* or
- 11 symptom* or awareness or stability or instability or labil* or impulsiv*)) or irritab*).ti,ab,kf.
- 12 136344
- 13 8 or 9
- 14 3 and 7 and 10

Embase (Ovid)

- 1 attention deficit hyperactivity disorder/
- 2 ("ADHD" or "ADDH" or "attention deficit" or "hyperactivity").ti,ab,kf.
- 3 1 or 2
- 4 exp sleep disorder/
- 5 exp sleep/

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

6 ("Sleep*" or "nocturnal" or "circadian" or "chronotype" or "insomnia" or "parasomnia" or
"dyssomnia").ti,ab,kf.
7 4 or 5 or 6
8 self control/ or emotion regulation/ or irritability/
9 emotional stability/ or emotional awareness/
10 (((emotion* or affect or mood) adj4 (regulation or dysregulation or control* or social* or
symptom* or awareness or stability or instability or labil* or impulsiv*)) or irritab*).ti,ab,kf.
11 8 or 9 or 10
12 3 and 7 and 11
13 limit 12 to conference abstract
14 12 not 13

Web of Science Core Collection (WOS.SCI: 1945 to 2024, WOS.AHCI: 1975 to 2024, WOS.ESCI: 2019 to 2024, WOS.SSCI: 1956 to 2024)

TS=("ADHD" or "ADDH" or "attention deficit" or "hyperkinetic") AND TS=("Sleep*" or "nocturnal" or "circadian" or "chronotype" or "insomnia" or "parasomnia" or "dyssomnia") AND TS=((emotion* or affect or mood) NEAR/3 (regulation or dysregulation or control* or social* or symptom* or awareness or stability or instability or labil* or impulsiv*) or irritab*)

Comments to Web of Science:
TS = Topic search = search in title, abstract and author key words
Near/2 = The adjacency operator (NEAR/n) retrieves records that contain search terms within a specified number (n) of words between the search terms in any order

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Ensignement Supérieur (ABES).

BMJ Open

The relationship between emotion dysregulation and sleep in children and adolescents with ADHD: protocol for a systematic review

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2025-099096.R1
Article Type:	Protocol
Date Submitted by the Author:	25-Apr-2025
Complete List of Authors:	Sørensen, Lin; University of Bergen, Department of Biological and Medical Psychology Jensen, Daniel; Betanien sykehus AS; Betanien Hospital Lykkebø, Amalie; University of Bergen, Department of Biological and Medical Psychology Adolfsson, Steinunn; University of Bergen, Department of Biological and Medical Psychology Holmen, Nina; The Norwegian ADHD Association Becker, Stephen; Cincinnati Children's Hospital Medical Center, Division of Behavioral Medicine and Clinical Psychology; University of Cincinnati College of Medicine, Department of Pediatrics Flo, Elisabeth; University of Bergen, Department of Clinical Psychology
Primary Subject Heading:	Paediatrics
Secondary Subject Heading:	Diagnostics, Mental health, Paediatrics, Patient-centred medicine, Public health
Keywords:	Attention Deficit Disorder with Hyperactivity, SLEEP MEDICINE, MENTAL HEALTH

SCHOLARONE™
Manuscripts

The relationship between emotion dysregulation and sleep in children and adolescents with ADHD: protocol for a systematic review

Lin Sørensen¹, Daniel A. Jensen², Amalie Lykkebø¹, Steinunn Adolfsdottir¹, Nina Holmen³, Stephen P. Becker^{4,5*}, & Elisabeth Flo-Groeneboom^{6*}

¹Department of Biological and Medical Psychology, University of Bergen, Bergen, Norway

²Betanien Hospital Bergen, Bergen, Norway

³The Norwegian ADHD Association, Oslo, Norway

⁴Division of Behavioral Medicine and Clinical Psychology, Center for ADHD, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA

⁵Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, OH, USA

⁶Department of Clinical Psychology, University of Bergen, Bergen, Norway

*Shared senior authorship.

Corresponding to:

Professor Lin Sørensen; lin.sorensen@uib.no.

Word count of manuscript (excl. title page, abstract, and references): 1874

ABSTRACT

Introduction: Over half of children and adolescents with ADHD have difficulties with emotional dysregulation and/or sleep, yet the interrelations between emotional regulation and sleep are not well-characterized in this population. This systematic review will address the relationship between these difficulties and investigate whether specific aspects of emotional dysregulation (EDR) are more strongly related with sleep problems in youth with ADHD.

Methods and analysis: We will adhere to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guideline for systematic reviews. A wide set of electronic databases will be searched for peer-reviewed quantitative studies investigating the relationship between EDR and sleep in children and adolescents (ages 5 to 18 years) with ADHD. In addition, the reference list of all studies will be searched for other relevant studies and Scopus used to search for citations of the included studies. We will also contact experts in the field to request published and unpublished studies. The primary outcome will be the effect size of the relationship between EDR and sleep in children and adolescents with ADHD. We will look at EDR and sleep broadly and also consider the multifaceted nature of both terms. Secondary outcomes will include which facets of EDR and sleep that have been measured and how they have been measured, developmental differences between children and adolescents with ADHD, and how and the extent to which studies controlled for use of CNS medications and co-occurring disorders in their study design and/or statistical analyses. The quality and risk of bias of the included studies will be assessed using the Mixed Methods Appraisal Tool (MMAT).

Ethics and dissemination: This protocol is for a review of studies and does not involve any new data collection and therefore does not need ethical or human

subjects approval. The results will be presented at international conferences and in a peer-reviewed journal.

PROSPERO registration number: CRD42024612984

Keywords: ADHD; emotion regulation; mood; sleep; circadian rhythm.

ARTICLE SUMMARY

Strengths and limitations of this study

- The study will be conducted by a team with expertise on ADHD, sleep, and emotion dysregulation in children and adolescents.
- We will consider the complexity of investigating the relation between sleep and emotion dysregulation in ADHD by taking into account the multifaceted nature of emotion dysregulation and sleep.
- The protocol was designed, and the systematic review will be conducted, in collaboration with a user organization to embrace the perspectives of patients with ADHD.
- A limitation is that we will predominantly include peer-reviewed studies.

INTRODUCTION

Everyday challenges that children and adolescents with attention-deficit/hyperactivity disorder (ADHD) experience often extend beyond what can be explained by the core

1
2
3 symptoms of inattention and hyperactivity/impulsivity^{1 2}. In particular, parents often
4 report their children with ADHD to have either sleep problems³ or problems regulating
5 strong emotions^{4 5}. Yet, there is still limited knowledge of how problems regulating
6 emotions and sleep are related with each other despite suggestions that they both
7 are causally related with ADHD⁶. It is thus clinically relevant and timely to conduct a
8 systematic review on the relationship between emotion dysregulation (EDR) and
9 sleep in ADHD to (1) understand the current evidence for an association, and (2)
10 provide summative information that can guide future research and clinical work in this
11 area.
12
13
14
15
16
17
18
19
20
21
22

23
24 EDR can be defined as when a child struggles significantly more than their
25 peers with adaptively modifying their emotional state and responses according to the
26 context they are in, to promote goal-oriented behavior^{4 5 7 8}. In ADHD, EDR is
27 prevalent across the lifespan^{4 5} and is found to be genetically connected with ADHD⁹
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
10. In ADHD, the focus has often been on EDR of negatively valenced emotions and
mood, although, also on struggles regulating sadness, worry, and positive emotions⁴.

Meta-analyses show that children³ and adolescents¹¹ with ADHD have
problems with numerous aspects of sleep. Caregivers³ and adolescents¹¹ both report
more subjective sleep difficulties than neurotypical controls, including problems falling
asleep, wakening during the nights, and early wakening in the mornings. Although
differences between youth with and without ADHD are not consistently present when
objective measures are used, meta-analytic findings indicate that actigraphy-
assessed sleep onset latency and polysomnography-assessed number of stage
shifts/hours sleep and apnea-hypopnea index are significantly higher in children with
ADHD than their peers³. Additionally, children with ADHD also more often had
delayed sleep phase and sleep disordered breathing. Poorer sleep quality has been

linked genetically with ADHD¹² and is reported consistently across the lifespan in ADHD¹³.

The aim is to conduct a systematic review of existing peer-reviewed studies to investigate if EDR and sleep are related in children and adolescents between 5 and 18 years old with ADHD. To our knowledge, such a systematic review has not been published in youth with ADHD, which is important for advancing future research and clinical care. The primary research question is the extent to which EDR is associated with poor, insufficient, and/or misaligned sleep in children and adolescents with ADHD. It is anticipated that EDR and sleep problems will be at least moderately associated. This expectation is in alignment with the meta-analytic results of average moderate effect sizes in the relationship between EDR and sleep in non-ADHD samples^{14 15}. We will be looking at EDR and sleep broadly and consider the multifaceted nature of both terms. The heterogenous nature and sample characteristics of ADHD are also important to consider in the relationship between EDR and sleep in ADHD. CNS medications seem to have a limited effect in improving EDR in ADHD¹⁶, whereas mixed findings are reported on their effects on sleep^{17 18}. The high prevalence of co-occurring disorders in ADHD^{4 19 20} and a stronger circadian preference towards eveningness²¹ may also affect EDR and sleep. Therefore, as secondary outcomes, we will consider if the effect sizes reported of the relationship between EDR and sleep are affected by how EDR and sleep are measured, age group included, and further if the effects are affected by how studies have controlled for the use of CNS medication, the presence of co-occurring disorders, and/or circadian preference.

METHODS AND ANALYSIS

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Ensignement Supérieur (ABES).

We will follow the guidelines as stated in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) in this proposed study.

The protocol for this proposed systematic review is pre-registered in PROSPERO. In the pre-registration, pilot work on this systematic review is noted based on a master thesis in clinical psychology²². We plan to start the study on 1 June 2025 and to complete it by 31 June 2026.

Search

We will conduct a search of numerous electronic databases, including PsychINFO, Medline, EMBASE, and Web of Science. For the specific syntax that will be used for each database, see online supplemental 1. In addition, the reference list of all studies will be searched for other relevant studies, and Scopus used to search for citations of the included studies. The search will be conducted with the support of the library consultancy at the University of Bergen. Duplicates will be removed by following the methods described by Hair et al.²³

Selection criteria

Study design

We will include all types of studies that have investigated the relationship between EDR and sleep in youth diagnosed with ADHD or in a sample with high symptom load of ADHD symptoms. This includes randomized controlled trials (RCTs) of sleep and/or EDR, other types of intervention studies, experimental studies (e.g., effects of

sleep restriction on EDR), population-, community-, or clinic-based studies of the concurrent correlations between EDR and sleep, and longitudinal studies.

Participants

We will include children and adolescents between 5 and 18 years old that have ADHD or elevated ADHD symptoms. In studies including a wider age range than our inclusion criteria, we will use a mean sample age ≥ 5 or ≤ 18 . We will define adolescence as starting at 10 years old in accordance with the World Health Organization’s definition²⁴ and define childhood as <10 years old and adolescence as ≥ 10 years old.

Reporting method and language

Original publications published in peer-reviewed journals that are written in English or in a Scandinavian language will be included. This could pose a limitation by not including relevant work published as pre-prints or grey literature, and or publications in other languages.

Outcomes

The primary outcome of this systematic review will be the effect of the relationship between EDR and sleep in children and adolescents with ADHD. Secondary research questions comprise i) whether *specific* aspects of EDR are more strongly related with *specific* sleep domains in children and adolescents with ADHD, ii) whether the method for measuring EDR and/or sleep influence the effects of the relationship between sleep and EDR, iii) whether there are a developmental differences between children and adolescents with ADHD in the relationship between EDR and sleep , iv) whether studies have controlled for use of CNS medications (or excluded participants based on medication use), and v) whether studies have

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Supérieur (ABES).

controlled for co-occurring psychiatric disorders in their study design and/statistical analyses, and circadian preference (morningness/eveningness)²¹. Both EDR and sleep are multi-faceted terms and important to consider when evaluating the secondary outcomes. EDR can comprise negative and positive expressions of emotions and mood, the recognition of and/or response to emotional expressions, and the regulation process per se, such as the use of strategies for coping with difficult emotions^{4 5}. Sleep can comprise sleep duration, sleep quality, sleep timing, night wakings, and daytime sleepiness; other sleep parameters will be coded if available.

Data collection

We will include studies and extract data in a two-step process. First, two independent investigators will screen for titles and abstracts of the studies after the initial search. Second, two independent investigators will read the full texts of all potentially relevant studies and decide on the final list of studies to include in the systematic review. Any disagreement after a discussion between the two independent investigators will be resolved by an independent third investigator. The data will be extracted on study characteristics, such as facets of EDR and sleep investigated, how EDR and sleep were measured, sample description (e.g., ADHD diagnosis or elevated ADHD symptoms), sample size, sample demographics (e.g., percentage of boys/girls, race/ethnicity, use of CNS medication, and psychiatric comorbidities), study design, and how use of CNS medication and comorbid disorders have been controlled for in the study design/statistical analyses. Additionally, the data will be extracted on effect sizes reported in the studies, such as Cohen's d and partial eta-squared (η^2_p). The reported effect sizes will be used for estimating the size of the association/effects between EDR and sleep quality (e.g., Cohen's d of 0.2, 0.5, and 0.8 will be used as

benchmarks for small, medium, and large effects, respectively, and n^2_p of 0.01, 0.06, and 0.14 as benchmarks for small, medium, and large effects, respectively²⁵). We will systematically contact authors when needing to gather unpublished information/data.

Study quality and risk of bias assessment

We will assess the quality and risk of bias of the included studies by using the Mixed Methods Appraisal Tool (MMAT; see Hong et al., 2018). This assessment will be done in connection with the data extraction, and will be assessed by at least two independent investigators, with disagreement resolved by a third independent investigator. Four of the authors (LS, DAJ, SA, and EFG) will train beforehand to calibrate the assessment of quality and risk of bias with the MMAT.

Patient and public involvement

Ms. Nina Holmen is the user and public involvement co-author to embrace the perspectives of patients with ADHD in the design of this protocol and further, in the data extraction and interpretations of results when conducting the systematic review.

ETHICS AND DISSEMINATION

Ethics

This is a protocol of an aggregated summary of existing studies, and as such does not involve any new human subjects data collection or require ethical approval.

Dissemination

1
2
3 The procedures for data inclusion and extraction will be described to ensure
4 transparency and replicability. The results of the systematic review will be
5
6 disseminated in an internationally peer-reviewed journal, in addition to at national
7
8 (e.g., organized by the Norwegian ADHD Association, the Norwegian ADHD
9
10 Research Network) and international conferences (e.g., ADHD World Congress,
11
12 Annual Meeting of the European Society for Child and Adolescent Psychiatry
13
14 Congress).

15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43 **Author Contributions** LS designed the study and developed and wrote this protocol
44 and the planned search strategies. EF-G co-designed the study and contributed
45
46 together with DAJ and SA in developing and writing the protocol and plan for search
47
48 strategies. AL was involved in the design of the study and piloting of search
49
50 strategies and data extraction. SPB and NH were involved in developing and writing
51
52 this protocol. LS is the guarantor for the article.
53
54
55
56
57
58
59
60

Funding The University of Bergen and the L. Meltzer Høyskolefond is funding this project and publication fees. Stephen Becker is supported in part by grants from the National Institute of Mental Health (NIMH; R01MH122415), the Institute of Education Sciences, U.S. Department of Education (IES; R305A200028, R324A240155, R305A240106), and the Cincinnati Children’s Research Foundation (CCRF). The content is solely the responsibility of the authors and does not necessarily represent the official views of the University of Bergen, IES, NIH, or CCRF.

Competing interests Lin Sørensen receives editorial honoraria as Associate Editor of Journal of the International Neuropsychological Society (JINS) and received a small research funding for speaking and conference support from Medice in 2023. In the past year, Stephen Becker discloses grant funding from the Institute of Education Sciences (IES), U.S. Department of Education; National Institute of Mental Health (NIMH); and Cincinnati Children’s Research Foundation (CCRF), and has received book honoraria from Guilford Press, editorial honoraria as Joint Editor of *JCPP Advances*, grant review panel honoraria from the IES, and educational seminar speaking fees and continuing education course royalties from PESI® and J&K Seminars. All other authors have no competing interest to declare.

Patient consent for publication Not required.

Open access

REFERENCES

1. Faraone SV, Bellgrove MA, Brikell I, et al. Attention-deficit/hyperactivity disorder. *Nat Rev Dis Primers* 2024;10(1):11. doi: 10.1038/s41572-024-00495-0 [published Online First: 2024/02/23]
2. Klein RG, Mannuzza S, Olazagasti MA, et al. Clinical and functional outcome of childhood attention-deficit/hyperactivity disorder 33 years later. *Arch Gen Psychiatry* 2012;69(12):1295-303. doi: 10.1001/archgenpsychiatry.2012.271 [published Online First: 2012/10/17]
3. Cortese S, Faraone SV, Konofal E, et al. Sleep in children with attention-deficit/hyperactivity disorder: meta-analysis of subjective and objective studies. *J Am Acad Child Adolesc Psychiatry* 2009;48(9):894-908. doi: 10.1097/CHI.0b013e3181ac09c9 [published Online First: 2009/07/25]
4. Faraone SV, Rostain AL, Blader J, et al. Practitioner Review: Emotional dysregulation in attention-deficit/hyperactivity disorder - implications for clinical

- recognition and intervention. *J Child Psychol Psychiatry* 2019;60(2):133-50. doi: 10.1111/jcpp.12899 [published Online First: 2018/04/07]
5. Shaw P, Stringaris A, Nigg J, et al. Emotion dysregulation in attention deficit hyperactivity disorder. *Am J Psychiatry* 2014;171(3):276-93. doi: 10.1176/appi.ajp.2013.13070966 [published Online First: 2014/02/01]
 6. Sonuga-Barke EJS, Becker SP, Bolte S, et al. Annual Research Review: Perspectives on progress in ADHD science - from characterization to cause. *J Child Psychol Psychiatry* 2023;64(4):506-32. doi: 10.1111/jcpp.13696 [published Online First: 2022/10/12]
 7. Gross JJ. Emotion regulation: affective, cognitive, and social consequences. *Psychophysiology* 2002;39(3):281-91. doi: 10.1017/s0048577201393198 [published Online First: 2002/09/06]
 8. Sheppes G, Suri G, Gross JJ. Emotion regulation and psychopathology. *Annu Rev Clin Psychol* 2015;11:379-405. doi: 10.1146/annurev-clinpsy-032814-112739 [published Online First: 2015/01/13]
 9. Astenvald R, Frick MA, Neufeld J, et al. Emotion dysregulation in ADHD and other neurodevelopmental conditions: a co-twin control study. *Child Adolesc Psychiatry Ment Health* 2022;16(1):92. doi: 10.1186/s13034-022-00528-0 [published Online First: 2022/11/30]
 10. Riglin L, Eyre O, Cooper M, et al. Investigating the genetic underpinnings of early-life irritability. *Transl Psychiatry* 2017;7(9):e1241. doi: 10.1038/tp.2017.212 [published Online First: 2017/09/28]
 11. Marten F, Keuppens L, Baeyens D, et al. Sleep parameters and problems in adolescents with and without ADHD: A systematic review and meta-analysis. *JCPP Adv* 2023;3(3):e12151. doi: 10.1002/jcv2.12151 [published Online First: 2023/09/18]
 12. Gregory AM, Agnew-Blais JC, Matthews T, et al. ADHD and Sleep Quality: Longitudinal Analyses From Childhood to Early Adulthood in a Twin Cohort. *J Clin Child Adolesc Psychol* 2017;46(2):284-94. doi: 10.1080/15374416.2016.1183499 [published Online First: 2016/08/04]
 13. Becker SP. ADHD and sleep: recent advances and future directions. *Curr Opin Psychol* 2020;34:50-56. doi: 10.1016/j.copsyc.2019.09.006 [published Online First: 2019/10/20]
 14. Palmer CA, Bower JL, Cho KW, et al. Sleep loss and emotion: A systematic review and meta-analysis of over 50 years of experimental research. *Psychol Bull* 2024;150(4):440-63. doi: 10.1037/bul0000410 [published Online First: 2023/12/21]
 15. Krizan Z, Boehm NA, Strauel CB. How emotions impact sleep: A quantitative review of experiments. *Sleep Med Rev* 2024;74:101890. doi: 10.1016/j.smrv.2023.101890 [published Online First: 2023/12/29]
 16. Lenzi F, Cortese S, Harris J, et al. Pharmacotherapy of emotional dysregulation in adults with ADHD: A systematic review and meta-analysis. *Neurosci Biobehav Rev* 2018;84:359-67. doi: 10.1016/j.neubiorev.2017.08.010 [published Online First: 2017/08/25]
 17. D'Aiello B, Gessi L, Menghini D, et al. Sleep disturbances in children with ADHD on methylphenidate monotherapy: The role of dysregulation profile. *Sleep Med* 2025;128:153-58. doi: 10.1016/j.sleep.2025.02.001 [published Online First: 2025/02/14]
 18. Faraone SV, Po MD, Komolova M, et al. Sleep-Associated Adverse Events During Methylphenidate Treatment of Attention-Deficit/Hyperactivity Disorder:

- A Meta-Analysis. *J Clin Psychiatry* 2019;80(3) doi: 10.4088/JCP.18r12210 [published Online First: 2019/05/16]
19. Cox RC, Olatunji BO. Sleep in the anxiety-related disorders: A meta-analysis of subjective and objective research. *Sleep Med Rev* 2020;51:101282. doi: 10.1016/j.smrv.2020.101282 [published Online First: 2020/02/29]
20. Marino C, Andrade B, Campisi SC, et al. Association Between Disturbed Sleep and Depression in Children and Youths: A Systematic Review and Meta-analysis of Cohort Studies. *JAMA Netw Open* 2021;4(3):e212373. doi: 10.1001/jamanetworkopen.2021.2373 [published Online First: 2021/03/23]
21. Gregory AM, Sadeh A. Annual Research Review: Sleep problems in childhood psychiatric disorders--a review of the latest science. *J Child Psychol Psychiatry* 2016;57(3):296-317. doi: 10.1111/jcpp.12469 [published Online First: 2015/09/29]
22. Lykkebø AB. The Association between Sleep and Emotional Dysregulation in Children and Adolescents diagnosed with Attention- Deficit/Hyperactivity Disorder: Systematic Review [Master]. University of Bergen, 2023.
23. Hair K, Bahr Z, Macleod M, et al. The Automated Systematic Search Deduplicator (ASySD): a rapid, open-source, interoperable tool to remove duplicate citations in biomedical systematic reviews. *bioRxiv* 2021 doi: 10.1101/2021.05.04.442412
24. WHO. Adolescent Health https://www.who.int/health-topics/adolescent-health/#tab=tab_12025 [cited 2025 04.22.].
25. Cohen J. Statistical power analysis for the behavioral sciences. Hillsdale, NJ: Lawrence Erlbaum 1988.

APA PsycInfo (Ovid)

- 1 attention deficit disorder/ or attention deficit disorder with hyperactivity/
- 2 hyperactivity/
- 3 ("ADHD" or "ADDH" or "attention deficit" or "hyperkinetic").ti,ab,id.
- 4 1 or 2 or 3
- 5 exp sleep wake disorders/
- 6 exp sleep/
- 7 ("Sleep*" or "nocturnal" or "circadian" or "chronotype" or "insomnia" or "parasomnia" or "dyssomnia").ti,ab,id.
- 8 5 or 6 or 7
- 9 emotional regulation/ or exp emotional control/ or emotional processing/ or exp self-control/
- 10 or self-regulation/ or socioemotional functioning/ or irritability/
- 11 (((emotion* or affect or mood) adj4 (regulation or dysregulation or control* or social* or symptom* or awareness or stability or instability or labil* or impulsiv*)) or irritab*).ti,ab,id.
- 12 9 or 10
- 13 4 and 8 and 11

Comments to OVID databases:
/ indicates that the search term is a subject heading
.ti,ab,id. Search term in title, abstract, or key concepts
kf. Search term in author keywords
Adj proximity operator indicates that search terms are close to each other. Adj2 means that search term two is the first or second (2) word after search term one, or vice versa

Ovid MEDLINE(R) and In-Process, In-Data-Review & Other Non-Indexed Citations and Daily

- 1 attention deficit disorder with hyperactivity/
- 2 ("ADHD" or "ADDH" or "attention deficit" or "hyperkinetic").ti,ab,kf.
- 3 1 or 2
- 4 exp sleep wake disorders/
- 5 exp sleep/
- 6 ("Sleep*" or "nocturnal" or "circadian" or "chronotype" or "insomnia" or "parasomnia" or "dyssomnia").ti,ab,kf.
- 7 4 or 5 or 6
- 8 self-control/ or emotional regulation/ or Irritable Mood/
- 9 (((emotion* or affect or mood) adj4 (regulation or dysregulation or control* or social* or symptom* or awareness or stability or instability or labil* or impulsiv*)) or irritab*).ti,ab,kf.
- 10 136344
- 11 8 or 9
- 12 3 and 7 and 10

Embase (Ovid)

- 1 attention deficit hyperactivity disorder/
- 2 ("ADHD" or "ADDH" or "attention deficit" or "hyperactivity").ti,ab,kf.
- 3 1 or 2
- 4 exp sleep disorder/
- 5 exp sleep/

6 ("Sleep*" or "nocturnal" or "circadian" or "chronotype" or "insomnia" or "parasomnia" or
7 "dyssomnia").ti,ab,kf.
8 4 or 5 or 6
9 self control/ or emotion regulation/ or irritability/
10 emotional stability/ or emotional awareness/
11 (((emotion* or affect or mood) adj4 (regulation or dysregulation or control* or social* or
12 symptom* or awareness or stability or instability or labil* or impulsiv*)) or irritab*).ti,ab,kf.
13 8 or 9 or 10
14 3 and 7 and 11
15 limit 12 to conference abstract
16 12 not 13

Web of Science Core Collection (WOS.SCI: 1945 to 2024, WOS.AHCI: 1975 to 2024, WOS.ESCI: 2019 to 2024, WOS.SSCI: 1956 to 2024)

TS=("ADHD" or "ADDH" or "attention deficit" or "hyperkinetic") AND TS=("Sleep*" or "nocturnal" or "circadian" or "chronotype" or "insomnia" or "parasomnia" or "dyssomnia") AND TS=((emotion* or affect or mood) NEAR/3 (regulation or dysregulation or control* or social* or symptom* or awareness or stability or instability or labil* or impulsiv*) or irritab*)

Comments to Web of Science:

TS = Topic search = search in title, abstract and author key words

Near/2 = The adjacency operator (NEAR/n) retrieves records that contain search terms within a specified number (n) of words between the search terms in any order