**Appendix.**

**Subjective and objective sleep alterations in medication-naïve children and adolescents with autism spectrum disorder: a systematic review and meta-analysis**

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# **eAppendix1. PRISMA checklist**

## **Table S1. PRISMA checklist**

| **Section and Topic** | **Item #** | **Checklist item** | **Location where item is reported** |
| --- | --- | --- | --- |
| **TITLE** | | |  |
| Title | 1 | Identify the report as a systematic review. | Title page |
| **ABSTRACT** | | |  |
| Abstract | 2 | See the PRISMA 2020 for Abstracts checklist. | Appendix p 6 |
| **INTRODUCTION** | | |  |
| Rationale | 3 | Describe the rationale for the review in the context of existing knowledge. | #2 |
| Objectives | 4 | Provide an explicit statement of the objective(s) or question(s) the review addresses. | #2 |
| **METHODS** | | |  |
| Eligibility criteria | 5 | Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses. | #3 |
| Information sources | 6 | Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. | #3 |
| Search strategy | 7 | Present the full search strategies for all databases, registers and websites, including any filters and limits used. | Appendix p 8 |
| Selection process | 8 | Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. | Figure 1, #5 |
| Data collection process | 9 | Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process. | #3 |
| Data items | 10a | List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. | #3 |
| 10b | List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. | #3 |
| Study risk of bias assessment | 11 | Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. | #3-4 |
| Effect measures | 12 | Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results. | #4 |
| Synthesis methods | 13a | Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). | #4 |
| 13b | Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions. | #4 |
| 13c | Describe any methods used to tabulate or visually display results of individual studies and syntheses. | #4 |
| 13d | Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. | #4 |
| 13e | Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). | #4 |
| 13f | Describe any sensitivity analyses conducted to assess robustness of the synthesized results. | #4 |
| Reporting bias assessment | 14 | Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). | #3-4 |
| Certainty assessment | 15 | Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. | Not applicable |
| **RESULTS** | | |  |
| Study selection | 16a | Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram. | Figure 1, #5 |
| 16b | Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. | Appendix pp 10-12 |
| Study characteristics | 17 | Cite each included study and present its characteristics. | Table 1, Appendix p 9 |
| Risk of bias in studies | 18 | Present assessments of risk of bias for each included study. | #6 |
| Results of individual studies | 19 | For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots. | Table 1 |
| Results of syntheses | 20a | For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies. | #5-6 |
| 20b | Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect. | #5-6 |
| 20c | Present results of all investigations of possible causes of heterogeneity among study results. | #6-7 |
| 20d | Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results. | #5-6 |
| Reporting biases | 21 | Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. | #6 |
| Certainty of evidence | 22 | Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed. | Not applicable |
| **DISCUSSION** | | |  |
| Discussion | 23a | Provide a general interpretation of the results in the context of other evidence. | #8 |
| 23b | Discuss any limitations of the evidence included in the review. | #9-10 |
| 23c | Discuss any limitations of the review processes used. | #9-10 |
| 23d | Discuss implications of the results for practice, policy, and future research. | #8-9 |
| **OTHER INFORMATION** | | |  |
| Registration and protocol | 24a | Provide registration information for the review, including register name and registration number, or state that the review was not registered. | #3 |
| 24b | Indicate where the review protocol can be accessed, or state that a protocol was not prepared. | #3 |
| 24c | Describe and explain any amendments to information provided at registration or in the protocol. | #3, Appendix p 13 |
| Support | 25 | Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review. | #11 |
| Competing interests | 26 | Declare any competing interests of review authors. | #11 |
| Availability of data, code and other materials | 27 | Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review. | #11 |

| **Section and Topic** | **Item #** | **Checklist item** | **Reported (Yes/No)** |
| --- | --- | --- | --- |
| **TITLE** | | |  |
| Title | 1 | Identify the report as a systematic review. | Yes |
| **BACKGROUND** | | |  |
| Objectives | 2 | Provide an explicit statement of the main objective(s) or question(s) the review addresses. | Yes |
| **METHODS** | | |  |
| Eligibility criteria | 3 | Specify the inclusion and exclusion criteria for the review. | Yes |
| Information sources | 4 | Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched. | Yes |
| Risk of bias | 5 | Specify the methods used to assess risk of bias in the included studies. | Yes |
| Synthesis of results | 6 | Specify the methods used to present and synthesise results. | Yes |
| **RESULTS** | | |  |
| Included studies | 7 | Give the total number of included studies and participants and summarise relevant characteristics of studies. | Yes |
| Synthesis of results | 8 | Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured). | Yes |
| **DISCUSSION** | | |  |
| Limitations of evidence | 9 | Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision). | Yes |
| Interpretation | 10 | Provide a general interpretation of the results and important implications. | Yes |
| **OTHER** | | |  |
| Funding | 11 | Specify the primary source of funding for the review. | Not applicable |
| Registration | 12 | Provide the register name and registration number. | Yes |

# **eAppendix 2. PRISMA abstract checklist**

## **Table S2. PRISMA abstract checklist**

# **eAppendix 3. Full search strategies (The last search was done on March 22nd, 2021)**

## **Table S3. Full search strategies**

|  |
| --- |
| PubMed (1086 articles were found) |
| ("autis\*" OR "Asperg\*" OR "pervasive developmental disorder") AND (sleep [tiab] OR sleepiness [tiab] OR alertness [tiab] OR vigilance [tiab]) AND (child [tiab] OR children [tiab] OR adolescent\* OR pediatric OR paediatric OR young people [tiab]) |
| Web of science (1595 articles were found) |
| (autis\* OR Asperg\* OR (pervasive developmental disorder)) AND (sleep OR sleepiness OR alertness OR vigilance) AND (child OR children OR adolescent\* OR pediatric OR paediatric OR young people) |
| Embase (3606 articles were found) |
| (autis\* OR Asperg\* OR (pervasive developmental disorder)) AND (sleep OR sleepiness OR alertness OR vigilance) AND (child OR children OR adolescent\* OR pediatric OR paediatric OR young people) |

# **eAppendix 4.** **The list of eligible articles**

**Allik H, Larsson J O and Smedje H** (2006) Sleep patterns of school-age children with Asperger syndrome or high-functioning autism. *Journal of Autism and Developmental Disorders*. **36**, 585-595.

**Anders T, Iosif A M, Schwichtenberg A J, Tang K and Goodlin-Jones B** (2012) Sleep and Daytime Functioning: A Short-term Longitudinal Study of Three Preschool-age Comparison Groups. *Ajidd-American Journal on Intellectual and Developmental Disabilities*. **117**, 275-290.

**Bruni O, Ferri R, Vittori E, Novelli L, Vignati M, Porfirio M C, Arico D, Bernabei P and Curatolo P** (2007) Sleep architecture and NREM alterations in children and adolescents with Asperger syndrome. *Sleep*. **30**, 1577-1585.

**Elia M, Ferri R, Musumeci S A, Del Gracco S, Bottitta M, Scuderi C, Miano G, Panerai S, Bertrand T and Grubar J C** (2000) Sleep in subjects with autistic disorder: a neurophysiological and psychological study. *Brain & Development*. **22**, 88-92.

**Harder R, Malow B A, Goodpaster R L, Iqbal F, Halbower A, Goldman S E, Fawkes D B, Wang L, Shi Y P, Baudenbacher F and Diedrich A** (2016) Heart rate variability during sleep in children with autism spectrum disorder. *Clinical Autonomic Research*. **26**, 423-432.

**Lambert A, Tessier S, Rochette A C, Scherzer P, Mottron L and Godbout R** (2016) Poor sleep affects daytime functioning in typically developing and autistic children not complaining of sleep problems: A questionnaire-based and polysomnographic study. *Research in Autism Spectrum Disorders*. **23**, 94-106.

**Malow B A, Marzec M L, McGrew S G, Wang L, Henderson L M and Stone W L** (2006) Characterizing sleep in children with autism spectrum disorders: A multidimensional approach. *Sleep*. **29**, 1563-1571.

**Miano S, Bruni V, Elia M, Trovato A, Smerieri A, Verrillo E, Roccella M, Terzano M G and Ferri R** (2007) Sleep in children with autistic spectrum disorder: A questionnaire and polysomnographic study. *Sleep Medicine*. **9**, 64-70.

**Mutluer T, Demirkaya S K and Abali O** (2016) Assessment of Sleep Problems and Related Risk Factors Observed in Turkish Children with Autism Spectrum Disorders. *Autism Research*. **9**, 536-542.

**Paavonen E J, Vehkalahti K, Vanhala R, Von Wendt L, Wendt T N V and Aronen E T** (2008) Sleep in children with Asperger syndrome. *Journal of Autism and Developmental Disorders*. **38**, 41-51.

**Pace M, Dumortier L, Favre-Juvin A, Guinot M and Bricout V A** (2016) Heart rate variability during sleep in children with autism spectrum disorders. *Physiology & Behavior*. **167**, 309-312.

**Reynolds A M, Soke G N, Sabourin K R, Hepburn S, Katz T, Wiggins L D, Schieve L A and Levy S E** (2019) Sleep Problems in 2-to 5-Year-Olds With Autism Spectrum Disorder and Other Developmental Delays. *Pediatrics*. **143**, 9.

**Romeo D M, Brogna C, Belli A, Lucibello S, Cutrona C, Apicella M, Mercuri E and Mariotti P** (2021) Sleep Disorders in Autism Spectrum Disorder Pre-School Children: An Evaluation Using the Sleep Disturbance Scale for Children. *Medicina-Lithuania*. **57**, 10.

**Tessier S, Lambert A, Scherzer P, Jemel B and Godbout R** (2015) REM sleep and emotional face memory in typically-developing children and children with autism. *Biological Psychology*. **110**, 107-114.

**Tse A C Y, Yu C C W and Lee P H** (2020) Comparing sleep patterns between children with autism spectrum disorder and children with typical development: A matched case-control study. *Autism*. **24**, 2298-2303.

**Tyagi V, Juneja M and Jain R** (2019) Sleep Problems and Their Correlates in Children with Autism Spectrum Disorder: An Indian Study. *Journal of Autism and Developmental Disorders*. **49**, 1169-1181.

# **eAppendix 5. The list of excluded articles by full text screening with exclusion reason**

## **Table S4. The list of excluded articles by full text screening with exclusion reason**

|  |  |
| --- | --- |
| **Author, year** | **Reason for exclusion** |
| Lehoux, et al. 2019 | data duplicate with Lambert et al. 2016 |
| Samanta, et al. 2020 | no control |
| Yavuz-Kodat, et al. 2020 | no control |
| Bartakovičová et al, 2019 | no data |
| Best et al, 2018 | no data |
| Delemere & Dounavi 2018 | no data |
| Gagnon et al, 2018 | no data |
| Gupta et al, 2020 | no data |
| Kuhlthau et al, 2018 | no data |
| Lawson et al, 2020 | no data |
| Malhi et al, 2019 | no data |
| McLay et al, 2020 | no data |
| Uren et al, 2019 | no data |
| Winkelman et al, 2018 | no data |
| Souders et al, 2009 | no medication naïve patient presented |
| Al-Farsi et al, 2019 | no medication-naïve patient presented |
| Alder et al, 2020 | no medication-naïve patient presented |
| Arazi et al, 2020 | no medication-naïve patient presented |
| Benson et al, 2019 | no medication-naïve patient presented |
| Cebreros-Paniagua et al, 2020 | no medication-naïve patient presented |
| Halstead et al, 2021 | no medication-naïve patient presented |
| Harris et al, 2018 | no medication-naïve patient presented |
| Holingue et al, 2021 | no medication-naïve patient presented |
| Johnson et al, 2018 | no medication-naïve patient presented |
| Koo et al, 2020 | no medication-naïve patient presented |
| Lindor et al, 2019 | no medication-naïve patient presented |
| Neumeyer et al, 2019 | no medication-naïve patient presented |
| Phung et al, 2019 | no medication-naïve patient presented |
| Restrepo et al, 2020 | no medication-naïve patient presented |
| Richdale & Schreck, 2019 | no medication-naïve patient presented |
| Shui et al, 2021 | no medication-naïve patient presented |
| Surtees et al, 2019 | no medication-naïve patient presented |
| Taylor & Siegel, 2019 | no medication-naïve patient presented |
| Taylor et al, 2018 | no medication-naïve patient presented |
| Yavuz-Kodat et al, 2019 | no medication-naïve patient presented |
| Zwaigenbaum et al, 2020 | no medication-naïve patient presented |
| Jeon et al, 2020 | out of scope |
| Johansson et al, 2018 | out of scope |
| Knuppel et al, 2018 | out of scope |
| McCrae et al, 2018 | out of scope |
| McGovney et al, 2020 | out of scope |
| Richdale & Roussis, 2018 | out of scope |
| Smidt et al, 2019 | out of scope |
| Tomkies et al, 2018 | out of scope |
| Tomkies et al, 2019 | out of scope |
| Toper, 2018 | out of scope |
| Vite et al, 2018 | out of scope |
| Baker et al, 2019 | studies for adult with autism spectrum disorder |
| Ballester et al, 2019 | studies for adult with autism spectrum disorder |
| Deserno et al, 2019 | studies for adult with autism spectrum disorder |
| Goldman et al, 2017 | studies for adult with autism spectrum disorder |

# **eAppendix 6. References of the excluded articles by full text screening**

**Al-Farsi O A, Al-Farsi Y M, Al-Sharbati M M and Al-Adawi S** (2019) Sleep habits and sleep disorders among children with autism spectrum disorders, intellectual disabilities and typically developing children in Oman: a case-control study. *Early Child Development and Care*. **189**, 2370-2380.

**Alder M L, Ye F, Run F, Bagai K, Fawkes D B, Peterson B T and Malow B A** (2020) Application of a novel actigraphy algorithm to detect movement and sleep/wake patterns in children with autism spectrum disorder. *Sleep Medicine*. **71**, 28-34.

**Arazi A, Meiri G, Danan D, Michaelovski A, Flusser H, Menashe I, Tarasiuk A and Dinstein I** (2020) Reduced sleep pressure in young children with autism. *Sleep*. **43**, 11.

**Baker E K, Richdale A L, Hazi A and Prendergast L A** (2019) Assessing a hyperarousal hypothesis of insomnia in adults with autism spectrum disorder. *Autism Research*. **12**, 897-910.

**Ballester P, Martínez M J, Javaloyes A, Inda M d M, Fernández N, Gázquez P, Aguilar V, Pérez A, Hernández L and Richdale A L** (2019) Sleep problems in adults with autism spectrum disorder and intellectual disability. *Autism Research*. **12**, 66-79.

**Bartakovičová K, Keményová P, Siklenková L, Ostatníková D and Babinská K** (2019) Sleep disturbances in children with autism spectrum disorder. *Act Nerv Super Rediviva*. **61**, 41-48.

**Benson S, Bender A M, Wickenheiser H, Naylor A, Clarke M, Samuels C H and Werthner P** (2019) Differences in sleep patterns, sleepiness, and physical activity levels between young adults with autism spectrum disorder and typically developing controls. *Developmental neurorehabilitation*. **22**, 164-173.

**Best V, Riedel A, Feige B, Tebartz van Elst L, Riemann D and Spiegelhalder K** (2018) Subjektive schlafbezogene Parameter bei Patienten mit Autismus-Spektrum-Störung. *Somnologie*. **22**, 262-266.

**Cebreros-Paniagua R, Ayala-Guerrero F and Mateos-Salgado E L** (2020) Sleep disturbances in patients with Asperger syndrome related to the severity of their symptoms. *Sleep and Vigilance*. **4**, 161-166.

**Delemere E and Dounavi K** (2018) Parent-implemented bedtime fading and positive routines for children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*. **48**, 1002-1019.

**Deserno M K, Borsboom D, Begeer S, Agelink Van Rentergem J A, Mataw K and Geurts H M** (2019) Sleep determines quality of life in autistic adults: A longitudinal study. *Autism Research*. **12**, 794-801.

**Gagnon K, Lambert A, Tessier S, Rochette A C and Godbout R** (2018) Association between REM sleep EEG connectivity and daytime core symptoms in children with Autism Spectrum Disorder. *Journal of Sleep Research*. **27**, 2.

**Goldman S, Alder M, Burgess H, Corbett B, Hundley R, Wofford D, Fawkes D, Wang L, Laudenslager M and Malow B** (2017) Characterizing sleep in adolescents and adults with autism spectrum disorders. *Journal of Autism and Developmental Disorders*. **47**, 1682-1695.

**Gupta A, Shukla G, Poornima S, Mohd A, Katoch J, Taneja D and Singhal N** (2020) 0969 early life sleep disturbance among children with autism spectrum disorders: a questionnaire-based retrospective study. *Sleep*. **43**, A368.

**Halstead E J, Joyce A, Sullivan E, Tywyn C, Davies K, Jones A and Dimitriou D** (2021) Sleep disturbances and patterns in children with neurodevelopmental conditions. *Frontiers in pediatrics*. **9**, 91.

**Harris J, Malow B and Werkhaven J** (2018) 0787 Descriptive Epidemiology of Obstructive Sleep Apnea in Children with Autism Spectrum Disorder. *Sleep*. **41**, A292.

**Holingue C, Volk H, Crocetti D, Gottlieb B, Spira A P and Mostofsky S H** (2021) Links between parent-reported measures of poor sleep and executive function in childhood autism and attention deficit hyperactivity disorder. *Sleep Health*. **7**, 375-383.

**Jeon M, Halstead E J and Dimitriou D** (2020) Cross-cultural comparison of sleep patterns of typically developing children and children with autism spectrum disorder in the UK and South Korea. *Journal of Sleep Research*. **29**, 347-347.

**Johansson A E E, Feeley C A, Dorman J S and Chasens E R** (2018) Characteristics of sleep in children with autism spectrum disorders from the Simons Simplex Collection. *Research in Autism Spectrum Disorders*. **53**, 18-30.

**Johnson C R, Smith T, DeMand A, Lecavalier L, Evans V, Gurka M, Swiezy N, Bearss K and Scahill L** (2018) Exploring sleep quality of young children with autism spectrum disorder and disruptive behaviors. *Sleep Medicine*. **44**, 61-66.

**Knuppel A, Telleus G K, Jakobsen H and Lauritsen M B** (2018) Quality of life in adolescents and adults with autism spectrum disorder: Results from a nationwide Danish survey using self reports and parental proxy-reports. *Research in Developmental Disabilities*. **83**, 247-259.

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**Kuhlthau K A, McDonnell E, Coury D L, Payakachat N and Macklin E** (2018) Associations of quality of life with health-related characteristics among children with autism. *Autism*. **22**, 804-813.

**Lawson L P, Richdale A L, Haschek A, Flower R L, Vartuli J, Arnold S R and Trollor J N** (2020) Cross-sectional and longitudinal predictors of quality of life in autistic individuals from adolescence to adulthood: The role of mental health and sleep quality. *Autism*. **24**, 954-967.

**Lehoux T, Carrier J and Godbout R** (2019) NREM sleep EEG slow waves in autistic and typically developing children: Morphological characteristics and scalp distribution. *Journal of Sleep Research*. **28**, e12775.

**Lindor E, Sivaratnam C, May T, Stefanac N, Howells K and Rinehart N** (2019) Problem behavior in autism spectrum disorder: considering core symptom severity and accompanying sleep disturbance. *Frontiers in psychiatry*, 487.

**Malhi P, Kaur A, Singhi P and Sankhyan N** (2019) Sleep dysfunction and behavioral daytime problems in children with autism spectrum disorders: A comparative study. *The Indian Journal of Pediatrics*. **86**, 12-17.

**McCrae C S, Chan W S, Deroche C B, Munoz M, McLean D, Davenport M, Muckerman J, Takahashi N, McCann D, McGovney K, Sahota P and Mazurek M** (2018) CBT FOR INSOMNIA IN CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD). *Sleep*. **41**, A298-A298.

**McGovney K D, Curtis A F, Mazurek M, Chan W S, Deroche C B, Munoz M, Davenport M, Takamatsu S, Takahashi N, Muckerman J, McCann D, Sahota P, Mills B and McCrae C S** (2020) NIGHTLY ASSOCIATIONS BETWEEN PRE-BEDTIME ACTIVITY, ACTIGRAPHIC LIGHT, AND SLEEP IN CHILDREN WITH ASD AND INSOMNIA. *Sleep*. **43**, A350-A351.

**McLay L, Hansen S G, Carnett A, France K G and Blampied N M** (2020) Attributions, causal beliefs, and help-seeking behavior of parents of children with autism spectrum disorder and sleep problems. *Autism*. **24**, 1829-1840.

**Neumeyer A M, Anixt J, Chan J, Perrin J M, Murray D, Coury D L, Bennett A, Farmer J and Parker R A** (2019) Identifying associations among co-occurring medical conditions in children with autism spectrum disorders. *Academic Pediatrics*. **19**, 300-306.

**Phung J N, Abdullah M M and Goldberg W A** (2019) Poor sleep quality among adolescents with ASD is associated with depressive symptoms, problem behaviors, and conflicted family relationships. *Focus on Autism and Other Developmental Disabilities*. **34**, 173-182.

**Restrepo B, Angkustsiri K, Taylor S L, Rogers S J, Cabral J, Heath B, Hechtman A, Solomon M, Ashwood P and Amaral D G** (2020) Developmental–behavioral profiles in children with autism spectrum disorder and co‐occurring gastrointestinal symptoms. *Autism Research*. **13**, 1778-1789.

**Richdale A and Roussis S** (2018) Sleep problem severity and behaviour in children with autism aged 2-to 5-years. *Journal of Sleep Research*. **27**, 2.

**Richdale A L and Schreck K A** (2019) Examining sleep hygiene factors and sleep in young children with It and without autism spectrum disorder. *Research in Autism Spectrum Disorders*. **57**, 154-162.

**Samanta P, Mishra D P, Panigrahi A, Mishra J, Senapati L K and Ravan J R** (2020) Sleep disturbances and associated factors among 2-6-year-old male children with autism in Bhubaneswar, India. *Sleep Medicine*. **67**, 77-82.

**Shui A M, Lampinen L A, Zheng S T and Katz T** (2021) Characteristics associated with parental estimates of sleep duration in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*. **80**, 15.

**Smidt S E, Ghorai A, Gehringer B, Dow H, Griffiths Z, Taylor S, Zhang J, Rader D, Almasy L, Brodkin E and Bucan M** (2019) Sleep in Autism Spectrum Disorder Without Intellectual Disability. *Neuropsychopharmacology*. **44**, 188-189.

**Souders M C, Mason T B, Valladares O, Bucan M, Levy S E, Mandell D S, Weaver T E and Pinto-Martin J** (2009) Sleep behaviors and sleep quality in children with autism spectrum disorders. *Sleep*. **32**, 1566-1578.

**Surtees A D, Richards C, Clarkson E L, Heald M, Trickett J, Denyer H, Crawford H and Oliver C** (2019) Sleep problems in autism spectrum disorders: A comparison to sleep in typically developing children using actigraphy, diaries and questionnaires. *Research in Autism Spectrum Disorders*. **67**, 101439.

**Taylor B, Palka T, Grados M, Peura C, Verdi M and Siegel M** (2018) 0841 Discrepancies between Parent-Reported and Observed Sleep Disturbance in Hospitalized Children with Autism Spectrum Disorder (ASD). *Sleep*. **41**, A312-A312.

**Taylor B J and Siegel M** (2019) 0783 Characterization Of Sleep Disturbance Profiles In Hospitalized Children With Autism Spectrum Disorder. *Sleep*. **42**, A314-A315.

**Tomkies A, Johnson R F and Mitchell R B** (2018) Obstructive sleep apnea in children with autism spectrum disorder. *Otolaryngology - Head and Neck Surgery (United States)*. **159**, P308.

**Tomkies A, Johnson R F, Shah G, Caraballo M, Evans P and Mitchell R B** (2019) Obstructive Sleep Apnea in Children With Autism. *Journal of Clinical Sleep Medicine*. **15**, 1469-1476.

**Toper O** (2018) Sleep Problems and Behavioral Interventions for Children With Autism Spectrum Disorders and Intellectual Disabilities. *Ankara Universitesi Egitim Bilimleri Fakultesi Ozel Egitim Dergisi-Ankara University Faculty of Educational Sciences Journal of Special Education*. **19**, 801-824.

**Uren J, Richdale A L, Cotton S M and Whitehouse A J** (2019) Sleep problems and anxiety from 2 to 8 years and the influence of autistic traits: a longitudinal study. *European Child & Adolescent Psychiatry*. **28**, 1117-1127.

**Vite T K G, Guerrero F A, Salgado E L M and Paniagua R C** (2018) Characterization of the Mu rhythm during the sleep of children with autism spectrum disorder level 1. *Salud Mental*. **41**, 109-116.

**Winkelman T, Naples A, Rolison M, McNaughton K, Day T, Hasselmo S, McAllister T, Ellison K, Jarzabek E and Lewis B** (2018) Children with Autism Demonstrate Atypical Resting EEG Correlates of Sleepiness. *Age (years)*. **9**, 15.

**Yavuz-Kodat E, Reynaud E, Geoffray M-M, Limousin N, Franco P, Bonnet-Brilhault F, Bourgin P and Schroder C M** (2020) Disturbances of continuous sleep and circadian rhythms account for behavioral difficulties in children with autism spectrum disorder. *Journal of Clinical Medicine*. **9**, 1978.

**Yavuz-Kodat E, Reynaud E, Geoffray M-M, Limousin N, Franco P, Bourgin P and Schroder C M** (2019) Validity of actigraphy compared to polysomnography for sleep assessment in children with autism spectrum disorder. *Frontiers in psychiatry*, 551.

**Zwaigenbaum L, Zaidman-Zait A, Duku E, Bennett T, Mirenda P, Smith I, Szatmari P, Vaillancourt T, Waddell C, Elsabbagh M, Georgiades S, Kerns C and Ungar W** (2020) Profiles of sleep problems among young children with autism spectrum disorders. *Paediatrics and Child Health (Canada)*. **25**, e23.

# **eAppendix 7. Exploratory investigation on publication bias as post-hoc analysis (independent T-tests between sleep parameters in two study designs [comparative studies versus non-comparative studies])**

In the main text, we addressed comparative studies only that compared sleep parameters between patients with autism spectrum disorder (ASD) and typically developing (TD) individuals. However, this concept could potentially make our results susceptible to publication bias since comparative studies may have the motivation to overrate ASD patients' sleep parameters compared to TD controls to publish positive results. Herein, we exploratory evaluated publication bias using the following process as a post-hoc analysis.

*Methods*

We performed an additional systematic search to identify observational studies that investigated sleep parameters in medication-naive ASD patients without controls under the age of 18. We systematically searched PubMed/Medline, Embase, and Web of Science from database inception to March 22, 2021, without any language restrictions. We used the original search strategies since they were appropriate to detect these studies (Appendix p 8). The study selection process that included title, abstract, and full-text screening was independently performed by two first authors (JHK and JK), and disagreement on this process was resolved by discussion.

After the screening process, data extraction was performed by two independent authors (JHK and JK). The following data were extracted for analysis: name of the first author, publication year, the country where the study was conducted, details of the study (number of participants, mean age and corresponding standard deviation [SD], diagnostic criteria for ASD), mean and SD for each outcome measure.

We performed independent T-tests for each sleep parameter to assess the differences between study designs (i.e., comparative studies [originally included in this study] versus non-comparative studies [newly identified study]). We also conducted F-tests before T-tests to assess the equality of two variances with the null hypothesis that the variances of two groups are equal. F-test was the only appropriate test to investigate the homogeneity of variance since we only had summarized results. The normality of each group was assumed because both the normality test and the Wilcoxon rank sum test were impossible to conduct. According to the results of F-tests, Student's T-tests (if the null hypothesis was not rejected) or Welch's T-tests (if the null hypothesis was rejected) were done. All statistical tests were performed using R version 4.1.0 software and its packages. All statistical tests were two-sided and statistical significance was set at P < 0.05.

*Results*

Among the 4277 citations that were found from a systematic search, 292 survived after the title and abstract screening. However, after the full-text screening, only one study was found to be eligible (Samanta et al. 2020), which reported the scores of the Children’s Sleep Habits Questionnaire (CSHQ) only. As a result of independent T-tests, there were statistically significant differences in the following CSHQ sleep parameters: bedtime resistance, sleep latency, sleep duration, sleep anxiety, and total sleep problem (see below table).

## **Table S5. Differences in sleep parameters between study designs (comparative versus non-comparative designs)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | k | N | Comparative design (mean ± SD) | k | N | Non-comparative design (mean ± SD) | *P* |
| Bedtime resistance | 2 | 22 | 8.25 ± 8.92 | 1 | 100 | 16.05 ± 2.57 | <0.0001a |
| Sleep latency (min) | 2 | 22 | 115.38 ± 58.12 | 1 | 100 | 153 ± 41.4 | <0.01a |
| Sleep duration (min) | 2 | 22 | 279.62 ± 228.96 | 1 | 100 | 426.6 ± 115.2 | <0.01a |
| Sleep anxiety | 2 | 22 | 6.56 ± 7.02 | 1 | 100 | 9.8 ± 2.12 | <0.05a |
| Night wakings | 2 | 22 | 4.34 ± 6.37 | 1 | 100 | 5.69 ± 1.83 | 0.335a |
| Sleep disordered breathing | 2 | 22 | 3.67 ± 3.65 | 1 | 100 | 5.06 ± 2.29 | 0.099a |
| Daytime sleepiness | 3 | 90 | 13.09 ± 1.68 | 1 | 100 | 12.84 ± 4.36 | 0.61b |
| Parasomnias | 2 | 22 | 9.3 ± 9.14 | 1 | 100 | 12.96 ± 4.4 | 0.08a |
| Total sleep problem | 3 | 436 | 48.85 ± 3.19 | 1 | 100 | 66.86 ± 14.77 | <0.0001a |
| Abbreviations: k=the number of studies, N=the number of patients with autism spectrum disorder, SD=standard deviation  a Welch's T-test was done since equality of two variances could not be assumed by the result of F-test.  b Student's T-test was done since equality of two variances could be assumed by the result of F-test. | | | | | | | |

## **Figure S1. Study selection flow for further investigation on publication bias (The last search was done on March 22nd, 2021)**

**Identification of studies via databases and registers**

Records identified from:

PubMed/MEDLINE (n=1086)

Embase (n=1595)

Web of Science (n=3606)

Records removed *before screening*:

Duplicate records removed

(n = 2010)

Records marked as ineligible by automation tools (n = 0)

Records removed for other reasons (n = 0)

**Identification**

Records excluded

(n = 3985)

Reports sought for retrieval

(n =292)

Reports assessed for eligibility

(n = 292)

Records screened

(n = 4277)

Studies included in review

(n = 1)

Reports of included studies

(Subjective measurement : n = 1)

**Screening**

Reports not retrieved

(n = 0)

291 reports excluded:

Out of scope (n=83)

Not enough data (n=75)

Patients took medication (n=73)

Comparative design (n=29)

Review article (n=12)

Not observational study (n=9)

Data duplication (n=6)

Patients included adults (n=4)

**Included**

## **eAppendix 7.1 The list of eligible articles** **for further investigation on publication bias**

1. Samanta, P., Mishra, D. P., Panigrahi, A., Mishra, J., Senapati, L. K., & Ravan, J. R. (2020). Sleep disturbances and associated factors among 2-6-year-old male children with autism in Bhubaneswar, India. *Sleep medicine*, *67*, 77–82.

## **Table S6. The list of excluded articles by full text screening with exclusion reason** **for further investigation on publication bias**

|  |  |
| --- | --- |
| **Reference** | **Reason for exclusion** |
| Baker, E. K., Richdale, A. L., Hazi, A., & Prendergast, L. A. (2019). Assessing a hyperarousal hypothesis of insomnia in adults with autism spectrum disorder. *Autism Research, 12*(6), 897-910. | Patients included adults |
| Ballester, P., Martínez, M. J., Javaloyes, A., Inda, M.-d.-M., Fernández, N., Gázquez, P., . . . Peiró, A. M. (2019). Sleep problems in adults with autism spectrum disorder and intellectual disability. Autism Research, 12(1), 66-79. | Patients included adults |
| Deserno, M. K., Borsboom, D., Begeer, S., Agelink Van Rentergem, J. A., Mataw, K., & Geurts, H. M. (2019). Sleep determines quality of life in autistic adults: A longitudinal study. *Autism Research, 12*(5), 794-801. | Patients included adults |
| Goldman, S., Alder, M., Burgess, H., Corbett, B., Hundley, R., Wofford, D., . . . Malow, B. (2017). Characterizing sleep in adolescents and adults with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 47*, 1682-1695. | Patients included adults |
| Allik, H., Larsson, J.-O., & Smedje, H. (2006). Sleep patterns of school-age children with Asperger syndrome or high-functioning autism. *Journal of Autism and Developmental Disorders, 36*, 585-595. | Comparative design |
| Anders, T., Iosif, A.-M., Schwichtenberg, A., Tang, K., & Goodlin-Jones, B. (2012). Sleep and daytime functioning: a short-term longitudinal study of three preschool-age comparison groups. *American Journal on Intellectual and Developmental Disabilities, 117*(4), 275-290. | Comparative design |
| Best, V., Riedel, A., Feige, B., Tebartz van Elst, L., Riemann, D., & Spiegelhalder, K. (2018). Subjective sleep-related parameters in patients with autism spectrum disorders. *Somnologie, 22*, 262-266. | Comparative design |
| Bruni, O., Ferri, R., Vittori, E., Novelli, L., Vignati, M., Porfirio, M. C., . . . Curatolo, P. (2007). Sleep architecture and NREM alterations in children and adolescents with Asperger syndrome. *Sleep, 30*(11), 1577-1585. | Comparative design |
| Delahaye, J., Kovacs, E., Sikora, D., Hall, T. A., Orlich, F., Clemons, T. E., . . . Kuhlthau, K. (2014). The relationship between health-related quality of life and sleep problems in children with autism spectrum disorders. *Research in autism spectrum disorders, 8*(3), 292-303. | Comparative design |
| Diomedi, M., Curatolo, P., Scalise, A., Placidi, F., Caretto, F., & Gigli, G. L. (1999). Sleep abnormalities in mentally retarded autistic subjects: Down's syndrome with mental retardation and normal subjects. *Brain and Development, 21*(8), 548-553. | Comparative design |
| Eyuboglu, M., & Eyuboglu, D. (2018). Sensory reactivity and sleep problems in toddlers with autism spectrum disorder and anxiety/depression symptoms in their mothers: are they related? *Early Child Development and Care*. | Comparative design |
| Fletcher, F. E., Knowland, V., Walker, S., Gaskell, M. G., Norbury, C., & Henderson, L. M. (2020). Atypicalities in sleep and semantic consolidation in autism. *Developmental Science, 23*(3), e12906. | Comparative design |
| Giannotti, F., Cortesi, F., Cerquiglini, A., & Bernabei, P. (2006). An open-label study of controlled-release melatonin in treatment of sleep disorders in children with autism. *Journal of Autism and Developmental Disorders, 36*, 741-752. | Comparative design |
| Goldman, S. E., Surdyka, K., Cuevas, R., Adkins, K., Wang, L., & Malow, B. A. (2009). Defining the sleep phenotype in children with autism. *Developmental neuropsychology, 34*(5), 560-573. | Comparative design |
| Guler, S., Yesil, G., Ozdil, M., Ekici, B., & Onal, H. (2016). Sleep disturbances and serum vitamin D levels in children with autism spectrum disorder. *Int. J. Clin. Exp. Med, 9*, 14691-14697. | Comparative design |
| Hering, E., Epstein, R., Elroy, S., Iancu, D. R., & Zelnik, N. (1999). Sleep patterns in autistic children. *Journal of Autism & Developmental Disorders, 29*(2). | Comparative design |
| Hirata, I., Mohri, I., Kato-Nishimura, K., Tachibana, M., Kuwada, A., Kagitani-Shimono, K., . . . Taniike, M. (2016). Sleep problems are more frequent and associated with problematic behaviors in preschoolers with autism spectrum disorder. *Research in developmental disabilities, 49*, 86-99. | Comparative design |
| Humphreys, J. S., Gringras, P., Blair, P. S., Scott, N., Henderson, J., Fleming, P. J., & Emond, A. M. (2014). Sleep patterns in children with autistic spectrum disorders: a prospective cohort study. *Archives of disease in childhood, 99*(2), 114-118. | Comparative design |
| Jeon, M., Halstead, E., & Dimitriou, D. (2020). *Cross-cultural comparison of sleep patterns of typically developing children and children with autism spectrum disorder in the UK and South Korea.* Paper presented at the Journal of Sleep Research. | Comparative design |
| Lambert, A., Tessier, S., Rochette, A.-C., Scherzer, P., Mottron, L., & Godbout, R. (2016). Poor sleep affects daytime functioning in typically developing and autistic children not complaining of sleep problems: A questionnaire-based and polysomnographic study. *Research in autism spectrum disorders, 23*, 94-106. | Comparative design |
| Lawson, L. P., Richdale, A. L., Haschek, A., Flower, R. L., Vartuli, J., Arnold, S. R., & Trollor, J. N. (2020). Cross-sectional and longitudinal predictors of quality of life in autistic individuals from adolescence to adulthood: The role of mental health and sleep quality. *Autism, 24*(4), 954-967. | Comparative design |
| Lehoux, T., Carrier, J., & Godbout, R. (2019). NREM sleep EEG slow waves in autistic and typically developing children: morphological characteristics and scalp distribution. *Journal of Sleep Research, 28*(4), e12775. | Comparative design |
| Malhi, P., Kaur, A., Singhi, P., & Sankhyan, N. (2019). Sleep dysfunction and behavioral daytime problems in children with autism spectrum disorders: a comparative study. *The Indian Journal of Pediatrics, 86*, 12-17. | Comparative design |
| Malow, B. A., Marzec, M. L., McGrew, S. G., Wang, L., Henderson, L. M., & Stone, W. L. (2006). Characterizing sleep in children with autism spectrum disorders: a multidimensional approach. *Sleep, 29*(12), 1563-1571. | Comparative design |
| Miano, S., Bruni, O., Elia, M., Trovato, A., Smerieri, A., Verrillo, E., . . . Ferri, R. (2007). Sleep in children with autistic spectrum disorder: a questionnaire and polysomnographic study. *Sleep medicine, 9*(1), 64-70. | Comparative design |
| Mutluer, T., Karakoc Demirkaya, S., & Abali, O. (2016). Assessment of sleep problems and related risk factors observed in T urkish children with A utism spectrum disorders. *Autism Research, 9*(5), 536-542. | Comparative design |
| Paavonen, E. J., Vehkalahti, K., Vanhala, R., von Wendt, L., Nieminen-von Wendt, T., & Aronen, E. T. (2008). Sleep in children with Asperger syndrome. *Journal of Autism and Developmental Disorders, 38*, 41-51. | Comparative design |
| Reynolds, A. M., Soke, G. N., Sabourin, K. R., Hepburn, S., Katz, T., Wiggins, L. D., . . . Levy, S. E. (2019). Sleep problems in 2-to 5-year-olds with autism spectrum disorder and other developmental delays. *Pediatrics, 143*(3). | Comparative design |
| Richdale, A. L., & Prior, M. R. (1995). The sleep/wake rhythm in children with autism. *European child & adolescent psychiatry, 4*, 175-186. | Comparative design |
| Romeo, D. M., Brogna, C., Belli, A., Lucibello, S., Cutrona, C., Apicella, M., . . . Mariotti, P. (2021). Sleep disorders in autism spectrum disorder pre-school children: an evaluation using the sleep disturbance scale for children. *Medicina, 57*(2), 95. | Comparative design |
| Tse, A. C., Yu, C., & Lee, P. H. (2020). Comparing sleep patterns between children with autism spectrum disorder and children with typical development: A matched case–control study. *Autism, 24*(8), 2298-2303. | Comparative design |
| Tyagi, V., Juneja, M., & Jain, R. (2019). Sleep problems and their correlates in children with autism spectrum disorder: An Indian study. *Journal of Autism and Developmental Disorders, 49*, 1169-1181. | Comparative design |
| Wang, G., Liu, Z., Xu, G., Jiang, F., Lu, N., Baylor, A., & Owens, J. (2016). Sleep disturbances and associated factors in Chinese children with autism spectrum disorder: a retrospective and cross-sectional study. *Child Psychiatry & Human Development, 47*, 248-258. | Comparative design |
| Delemere, E., & Dounavi, K. (2018). Parent-implemented bedtime fading and positive routines for children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 48*, 1002-1019. | Not observational study |
| Johnson, C. R., Turner, K. S., Foldes, E., Brooks, M. M., Kronk, R., & Wiggs, L. (2013). Behavioral parent training to address sleep disturbances in young children with autism spectrum disorder: a pilot trial. *Sleep medicine, 14*(10), 995-1004. | Not observational study |
| Moon, E. C., Corkum, P., & Smith, I. M. (2011). Case study: A case-series evaluation of a behavioral sleep intervention for three children with autism and primary insomnia. *Journal of pediatric psychology, 36*(1), 47-54. doi:10.1093/jpepsy/jsq057 | Not observational study |
| Weiskop, S., Matthews, J., & Richdale, A. (2001). Treatment of sleep problems in a 5-year-old boy with autism using behavioural principles. *Autism, 5*(2), 209-221. | Not observational study |
| Garstang, J., & Wallis, M. (2006). Randomized controlled trial of melatonin for children with autistic spectrum disorders and sleep problems. *Child: care, health and development, 32*(5), 585-589. | Not observational study |
| Goldman, S. E., Adkins, K. W., Calcutt, M. W., Carter, M. D., Goodpaster, R. L., Wang, L., . . . Malow, B. A. (2014). Melatonin in children with autism spectrum disorders: endogenous and pharmacokinetic profiles in relation to sleep. *Journal of Autism and Developmental Disorders, 44*, 2525-2535. | Not observational study |
| Malow, B., Adkins, K. W., McGrew, S. G., Wang, L., Goldman, S. E., Fawkes, D., & Burnette, C. (2012). Melatonin for sleep in children with autism: a controlled trial examining dose, tolerability, and outcomes. *Journal of Autism and Developmental Disorders, 42*, 1729-1737. | Not observational study |
| Paavonen, E. J., Nieminen-von Wendt, T., Vanhala, R., Aronen, E. T., & von Wendt, L. (2003). Effectiveness of melatonin in the treatment of sleep disturbances in children with Asperger disorder. *Journal of Child and Adolescent Psychopharmacology, 13*(1), 83-95. | Not observational study |
| Wright, B., Sims, D., Smart, S., Alwazeer, A., Alderson-Day, B., Allgar, V., . . . Jardine, J. (2011). Melatonin versus placebo in children with autism spectrum conditions and severe sleep problems not amenable to behaviour management strategies: a randomised controlled crossover trial. *Journal of Autism and Developmental Disorders, 41*, 175-184. | Not observational study |
| Malow, B., Adkins, K., Clemons, T., Goldman, S., Molloy, C., Wofford, D., . . . Surdyka, K. (2011). *Effects of a standardized pamphlet on sleep latency in children with autism.* Paper presented at the Sleep. | Data duplication |
| McLay, L., France, K., Blampied, N., & Hunter, J. (2019). Using functional behavioral assessment to treat sleep problems in two children with autism and vocal stereotypy. *International Journal of Developmental Disabilities, 65*(3), 175-184. | Data duplication |
| Tomkies, A., Johnson, R. F., Shah, G., Caraballo, M., Evans, P., & Mitchell, R. B. (2019). Obstructive sleep apnea in children with autism. *Journal of Clinical Sleep Medicine, 15*(10), 1469-1476. | Data duplication |
| Wirojanan, J., Jacquemont, S., Diaz, R., Bacalman, S., Anders, T. F., Hagerman, R. J., & Goodlin-Jones, B. L. (2009). The efficacy of melatonin for sleep problems in children with autism, fragile X syndrome, or autism and fragile X syndrome. *Journal of Clinical Sleep Medicine, 5*(2), 145-150. | Data duplication |
| Yavuz-Kodat, E., Reynaud, E., Geoffray, M.-M., Limousin, N., Franco, P., Bonnet-Brilhault, F., . . . Schroder, C. M. (2020). Disturbances of continuous sleep and circadian rhythms account for behavioral difficulties in children with autism spectrum disorder. *Journal of clinical medicine, 9*(6), 1978. | Data duplication |
| Yavuz-Kodat, E., Reynaud, E., Geoffray, M.-M., Limousin, N., Franco, P., Bonnet-Brilhault, F., . . . Schroder, C. M. (2020). Disturbances of continuous sleep and circadian rhythms account for behavioral difficulties in children with autism spectrum disorder. *Journal of clinical medicine, 9*(6), 1978. | Data duplication |
| Abel, E., Schwichtenberg, A., & Brodhead, M. (2017). 0916 assessing sleep problems within the context of early behavioral intervention for autism spectrum disorder. *Sleep, 40*, A340-A341. | Not enough data |
| Aguilar Andujar, M., Sanchez, G., Menendez De Leon, C., Ramos, I., & Marquez, A. (2014). *Sleep characteristics in children with autism spectrum disorder.* Paper presented at the Journal of Sleep Research. | Not enough data |
| Ayala-Guerrero, F., Mateos, E. L., Villamar, C., García-Vite, T., Alcántara, M., & Gutierrez, C. A. (2019). The patient sleep of the autista spectrum and theory of the mind. Sleep Science, 12, 18. Retrieved from https://www.embase.com/search/results?subaction=viewrecord&id=L630029412&from=export | Not enough data |
| Ballester, P., Martinez Madrid, M., Canet, T., Richdale, A., & Peiro, A. (2020). *Sleep problems across a lifespan of children, adolescents and adults with autism spectrum disorder and intellectual disability at a glance.* Paper presented at the Journal of Sleep Research. | Not enough data |
| Bartakovicova, K., Kemenyova, P., Siklenkova, L., Ostatnikova, D., & Babinska, K. (2019). Sleep disturbances in children with autism spectrum disorder. *Activitas Nervosa Superior Rediviva, 61*(2), 41-48. Retrieved from <Go to ISI>://WOS:000489092000001 | Not enough data |
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# **eAppendix 8. Unification of sleep parameters assessed by subjective measurements**

## **Table S7. Unification of sleep parameters assessed by subjective measurements**

|  |  |  |  |
| --- | --- | --- | --- |
| Sleep measurements | Original parameters | Used as original | United to |
| CSHQ | Bedtime resistance | Bedtime resistance |  |
|  | Daytime sleepiness | Daytime sleepiness |  |
|  | Night waking | Night waking |  |
|  | Parasomnias | Parasomnias |  |
|  | Sleep anxiety | Sleep anxiety |  |
|  | Sleep disordered breathing | Sleep disordered breathing |  |
|  | Sleep duration | Sleep duration |  |
|  | Sleep latency | Sleep latency |  |
|  | Total score | Total score |  |
| SDSC | Disorders in initiating and maintaining sleep | Disorders in initiating and maintaining sleep |  |
|  | Disorders of arousal |  | Parasomnias |
|  | Disorders of excessive somnolence |  | Daytime sleepiness |
|  | Sleep breathing disorder |  | Sleep disordered breathing |
|  | Sleep hyperhydrosis | Sleep hyperhydrosis |  |
|  | Sleep-wake transition disorders | Sleep-wake transition disorders |  |
|  | Total score |  | Total score |
| PSQ | Breathing problems |  | Sleep disordered breathing |
|  | Insomnia |  | Sleep latency |
|  | Other sleep problems | Other sleep problems |  |
|  | Periodic movement disorder of sleep | Periodic movement disorder of sleep |  |
|  | Sleepiness |  | Daytime sleepiness |
|  | Snoring | Snoring |  |
|  | Total score |  | Total score |
| Sleep diary | Sleep latency |  | Sleep latency |
|  | Sleep quality | Sleep quality |  |
|  | Total sleep time | Total sleep time |  |
| Sleep log assessment | Sleep duration |  | Sleep duration |
|  | Sleep efficiency | Sleep efficiency |  |
|  | Sleep latency |  | Sleep latency |

Abbreviations: CSHQ, the Children's Sleep Habits Questionnaire; SDSC, the Sleep Disturbance Scale for Children; PSQ, Pediatric Sleep questionnaire

# **eAppendix 9. Result of the study quality assessment (Newcastle-Ottawa scale)**

## **Table S8. Result of the Newcastle-Ottawa scale**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Author, year | Selection | | | | Comparability | Exposure | | | Total score | Study quality |
| **Definition of cases** | **Representativeness of the cases** | **Selection of cases** | **Definition of controls** |  | **Ascertainment of exposure** | **Same method of ascertainment** | **Non-response rate** |
| Allik 2006 | \* | \* | \* | \* | \* | \* | \* | \* | 8 | **Good** |
| Anders 2012 | \* | \* | \* | \* | \* | \* | \* | \* | 8 | **Good** |
| Bruni 2007 | \* | \* | No description was presented about the selection of cases | \* | Study did not control for any factor. | \* | \* | \* | 6 | **Poor** |
| CY Tse 2020 | \* | \* | \* | \* | \* | \* | \* | \* | 8 | **Good** |
| Elia 2000 | \* | \* | \* | No description was presented about the source of controls | \* | \* | \* | Non-response rate was not identical between cases and controls. | 6 | **Good** |
| Harder 2016 | \* | \* | \* | \* | \* | \* | \* | \* | 8 | **Good** |
| Lambert 2016 | \* | \* | \* | \* | \*\* | \* | \* | \* | 9 | **Good** |
| Malow 2006 | \* | \* | \* | \* | \*\* | \* | \* | \* | 9 | **Good** |
| Miano 2007 | \* | \* | \* | \* | \* | \* | \* | \* | 8 | **Good** |
| Mutleur 2016 | \* | \* | \* | \* | \*\* | \* | \* | \* | 9 | **Good** |
| Paavonen 2007 | \* | \* | \* | \* | Study did not control for any factor. | \* | \* | \* | 7 | **Poor** |
| Pace 2016 | \* | \* | \* | \* | \* | \* | \* | \* | 8 | **Good** |
| Reynolds 2018 | \* | \* | \* | \* | \*\* | \* | \* | \* | 9 | **Good** |
| Romeo 2021 | \* | \* | \* | \* | \* | \* | \* | \* | 8 | Good |
| Tessier 2015 | \* | \* | \* | no description about the source of controls | \*\* | \* | \* | \* | 8 | Good |
| Tyagi 2018 | \* | \* | \* | \* | \* | \* | \* | Non-response rate was not identical between cases and controls. | 7 | Good |

# **eAppendix 10. Statistical results of meta-regression analyses – Publication year, mean age of ASD group, Percentage of boys in ASD group**

## **Table S9. Statistical results of meta-regression analyses - Actigraphy**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sleep parameters | Meta-regression moderators | k | Coefficient (95% CI) | p value | NA reason |
| Sleep efficiency (%) | Publication year | 4 | -0.0057 (-0.1290, 0.1176) | 0.9277 |  |
| Mean age of ASD group | 4 | -0.0491 (-0.2560, 0.1578) | 0.6419 |  |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Sleep latency (min) | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Total sleep time (min) | Publication year | 4 | -0.0524 (-0.1599, 0.0551) | 0.3394 |  |
| Mean age of ASD group | 4 | 0.0141 (-0.2249, 0.2530) | 0.9081 |  |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Wake after sleep onset (min) | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |

Abbreviations: ASD, autism spectrum disorders; CI, confidence interval; NA, not available; k, the number of studies.

## **Table S10. Statistical results of meta-regression analyses - Polysomnography**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sleep parameters | Meta-regression moderators | k | Coefficient (95% CI) | p value | NA reason |
| Number of awakenings per hour | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| REM density (no./h REM sleep) | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| REM latency (min) | Publication year | 6 | 0.0338 (-0.0357, 0.1033) | 0.3407 |  |
| Mean age of ASD group | 6 | -0.1711 (-0.3753, 0.0330) | 0.1004 |  |
| Percentage of boys in ASD group | 5 | 0.0072 (-0.0659, 0.0802) | 0.8475 |  |
| REM sleep (%) | Publication year | 6 | 0.0161 (-0.0416, 0.0737) | 0.585 |  |
| Mean age of ASD group | 6 | 0.0584 (-0.1268, 0.2436) | 0.5366 |  |
| Percentage of boys in ASD group | 5 | -0.0114 (-0.0606, 0.0378) | 0.6502 |  |
| S1 (%) | Publication year | 6 | 0.0448 (-0.0126, 0.1022) | 0.1259 |  |
| Mean age of ASD group | 6 | 0.1198 (-0.0657, 0.3052) | 0.2055 |  |
| Percentage of boys in ASD group | 5 | 0.0221 (-0.0272, 0.0714) | 0.3805 |  |
| S2 (%) | Publication year | 6 | 0.0426 (-0.0147, 0.0999) | 0.1446 |  |
| Mean age of ASD group | 6 | 0.0447 (-0.1484, 0.2379) | 0.6499 |  |
| Percentage of boys in ASD group | 5 | 0.0062 (-0.0432, 0.0556) | 0.8054 |  |
| Slow wave sleep (%) | Publication year | 6 | -0.1196 (-0.1817, -0.0574) | **<0.0005** |  |
| Mean age of ASD group | 6 | -0.1755 (-0.5796, 0.2287) | 0.3947 |  |
| Percentage of boys in ASD group | 5 | -0.0512 (-0.1222, 0.0198) | 0.1578 |  |
| Sleep efficiency (%) | Publication year | 6 | 0.0410 (-0.0219, 0.1038) | 0.2014 |  |
| Mean age of ASD group | 6 | 0.1546 (-0.0405, 0.3497) | 0.1204 |  |
| Percentage of boys in ASD group | 5 | 0.0340 (-0.0195, 0.0876) | 0.2132 |  |
| Sleep latency (min) | Publication year | 6 | -0.0374 (-0.0959, 0.0210) | 0.2096 |  |
| Mean age of ASD group | 6 | -0.0409 (-0.2574, 0.1755) | 0.7108 |  |
| Percentage of boys in ASD group | 5 | -0.0438 (-0.0966, 0.0089) | 0.1029 |  |
| Sleep period time (min) | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |

Abbreviations: ASD, autism spectrum disorders; CI, confidence interval; NA, not available; k, the number of studies; REM, rapid eye movement.

## **Table S10. Continued**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sleep parameters | Meta-regression moderators | k | Coefficient (95% CI) | p value | NA reason |
| Stage shift per hour | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Time in bed (min) | Publication year | 4 | 0.0575 (-0.0133, 0.1282) | 0.1113 |  |
| Mean age of ASD group | 4 | -0.0691 (-0.3269, 0.1887) | 0.5992 |  |
| Percentage of boys in ASD group | 4 | 0.0012 (-0.1076, 0.1100) | 0.9827 |  |
| Total sleep time (min) | Publication year | 6 | 0.0903 (0.0172, 0.1635) | **<0.05** |  |
| Mean age of ASD group | 6 | 0.0011 (-0.3473, 0.3495) | 0.995 |  |
| Percentage of boys in ASD group | 5 | -0.0059 (-0.0614, 0.0495) | 0.8336 |  |
| Wake after sleep onset (min) | Publication year | 5 | 0.0577 (-0.0078, 0.1232) | 0.0843 |  |
| Mean age of ASD group | 5 | 0.0620 (-0.2086, 0.3327) | 0.6532 |  |
| Percentage of boys in ASD group | 5 | 0.0526 (0.0027, 0.1025) | **<0.05** |  |

Abbreviations: ASD, autism spectrum disorders; CI, confidence interval; NA, not available; k, the number of studies; REM, rapid eye movement.

## **Table S11. Statistical results of meta-regression analyses - Actigraphy + Polysomnography**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sleep parameters | Meta-regression moderators | k | Coefficient (95% CI) | p value | NA reason |
| Sleep efficiency (%) | Publication year | 10 | 0.0188 (-0.0365, 0.0741) | 0.5056 |  |
| Mean age of ASD group | 10 | -0.0032 (-0.1325, 0.1261) | 0.9616 |  |
| Percentage of boys in ASD group | 8 | 0.0079 (-0.0284, 0.0443) | 0.6696 |  |
| Sleep latency (min) | Publication year | 8 | -0.0588 (-0.1173, -0.0002) | **<0.05** |  |
| Mean age of ASD group | 8 | 0.0815 (-0.0099, 0.1728) | 0.0804 |  |
| Percentage of boys in ASD group | 7 | -0.0100 (-0.0595, 0.0396) | 0.6935 |  |
| Time in bed (min) | Publication year | 5 | 0.0693 (0.0080, 0.1307) | **<0.01** |  |
| Mean age of ASD group | 5 | 0.0465 (-0.272, 0.365) | 0.7749 |  |
| Percentage of boys in ASD group | 4 | 0.0012 (-0.1076, 0.1100) | 0.9827 |  |
| Total sleep time (min) | Publication year | 10 | 0.0285 (-0.0399, 0.0970) | 0.414 |  |
| Mean age of ASD group | 10 | 0.0074 (-0.1575, 0.1722) | 0.9302 |  |
| Percentage of boys in ASD group | 8 | -0.0021 (-0.0428, 0.0386) | 0.9187 |  |

Abbreviation: ASD, autism spectrum disorders; CI, confidence interval; NA, not available; k, the number of studies.

## **Table S12. Statistical results of meta-regression analyses - Subjective measurements**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sleep parameters | Meta-regression moderators | k | Coefficient (95% CI) | p value | NA reason |
| Daytime sleepiness | Publication year | 7 | -0.0122 (-0.0638, 0.0394) | 0.6432 |  |
| Mean age of ASD group | 7 | 0.0698 (0.0232, 0.1164) | **<0.005** |  |
| Percentage of boys in ASD group | 6 | -0.0710 (-0.2077, 0.0657) | 0.309 |  |
| Parasomnias | Publication year | 5 | -0.0565 (-0.1061, -0.0069) | **<0.05** |  |
| Mean age of ASD group | 5 | 0.0716 (-0.0520, 0.1953) | 0.2561 |  |
| Percentage of boys in ASD group | 4 | -0.0601 (-0.3151, 0.1948) | 0.6439 |  |
| Sleep disordered breathing | Publication year | 6 | -0.0530 (-0.1483, 0.0422) | 0.2753 |  |
| Mean age of ASD group | 6 | 0.1078 (-0.0308, 0.2464) | 0.1274 |  |
| Percentage of boys in ASD group | 5 | -0.0397 (-0.3937, 0.3144) | 0.8263 |  |
| Sleep latency | Publication year | 5 | 0.0387 (-0.0296, 0.1071) | 0.2741 |  |
| Mean age of ASD group | 5 | 0.0487 (-0.2358, 0.3332) | 0.7371 |  |
| Percentage of boys in ASD group | 4 | -0.0936 (-0.1665, -0.0207) | **<0.05** |  |
| Bedtime resistance | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Disorders in initiating and maintaining sleep | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Night waking | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Sleep anxiety | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |

Abbreviations: ASD, autism spectrum disorders; CI, confidence interval; NA, not available; k, the number of studies.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sleep parameters | Meta-regression moderators | k | Coefficient (95% CI) | p value | NA reason |
| Sleep duration | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Sleep hyperhidrosis | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Sleep-wake transition disorders | Publication year |  |  |  | k<4 |
| Mean age of ASD group |  |  |  | k<4 |
| Percentage of boys in ASD group |  |  |  | k<4 |
| Total sleep problem | Publication year | 7 | -0.0569 (-0.1060, -0.0078) | **<0.05** |  |
| Mean age of ASD group | 6 | 0.0693 (0.0171, 0.1215) | **<0.01** |  |
| Percentage of boys in ASD group | 5 | -0.0784 (-0.2434, 0.0866) | 0.3515 |  |

## **Table S12. Continued**

Abbreviations: ASD, autism spectrum disorders; CI, confidence interval; NA, not available; k, the number of studies.

# **eAppendix 11. Statistical results of the subgroup analyses - Inclusion of Intellectual disability**

## **Table S13. Statistical results of the subgroup analyses(Inclusion of Intellectual disability) - Actigraphy**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sleep parameters | Subgroup | k | Meta-analysis | Heterogeneity | | p values | NA reason |
| Hedges' g (95% CI) | Q value | *I2* (%) |
| Sleep efficiency (%) | Included | 1 | -1.0694 (-1.8513, -0.2875) |  |  | 0.1164 |  |
| Excluded | 3 | -0.3275 (-0.8240, 0.1689) | 5.79 | 65.5 |
| Sleep latency (min) | NA |  |  |  |  |  | All individual studies excluded ID patients |
| Total sleep time (min) | Included | 1 | -1.3268 (-1.7771, -0.8766) |  |  | **<0.001** |  |
| Excluded | 3 | -0.3729 (-0.6867, -0.0592) | 2.78 | 28 |
| Wake after sleep onset (min) | Included | 1 | 0.7831 (0.4571, 1.1090) |  |  | **<0.005** |  |
| Excluded | 1 | 0.0677 (-0.2673, 0.4027) |  |  |

Abbreviations: CI, confidence interval; ID, intellectual disability; k, the number of studies; NA, not available.

## **Table S14. Statistical results of the subgroup analyses(Inclusion of Intellectual disability) - Polysomnography**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sleep parameters | Subgroup | k | Meta-analysis | Heterogeneity | | p values | NA reason |
| Hedges' g (95% CI) | Q value | *I2* (%) |
| Number of awakenings per hour | Included | 2 | 0.2226 (-0.6302, 1.0754) | 2.46 | 59.4 | 0.9581 |  |
| Excluded | 1 | 0.2664 (-1.1273, 1.6601) |  |  |
| REM density (no./h REM sleep) |  |  |  |  |  |  | All individual studies excluded ID patients |
| REM latency (min) | Included | 2 | -0.7620 (-1.3088, -0.2151) | 0 | 0 | **<0.05** |  |
| Excluded | 4 | -0.0161 (-0.4008, 0.3687) | 2.65 | 0 |
| REM sleep (%) | Included | 2 | -0.3223 (-0.8515, 0.2069) | 0.01 | 0 | 0.9854 |  |
| Excluded | 4 | -0.3284 (-0.7161, 0.0593) | 2.94 | 0 |
| S1 (%) | Included | 2 | 0.3085 (-0.2204, 0.8374) | 0 | 0 | 0.5105 |  |
| Excluded | 4 | 0.0885 (-0.2983, 0.4753) | 4.39 | 31.7 |
| S2 (%) | Included | 2 | -0.4534 (-0.9864, 0.0796) | 0 | 0 | 0.3205 |  |
| Excluded | 4 | -0.1198 (-0.5061, 0.2665) | 3.67 | 18.2 |
| Slow wave sleep (%) | Included | 2 | 0.3412 (-0.9681, 1.6506) | 0.01 | 0 | 0.8102 |  |
| Excluded | 4 | 0.1430 (-0.8074, 1.0933) | 18.44 | 83.7 |
| Sleep efficiency (%) | Included | 2 | -0.5400 (-1.2098, 0.1298) | 0.06 | 0 | 0.8003 |  |
| Excluded | 4 | -0.6477 (-1.1458, -0.1496) | 5.97 | 49.7 |
| Sleep latency (min) | Included | 2 | 0.5025 (-0.1162, 1.1212) | 0.03 | 0 | 0.7429 |  |
| Excluded | 4 | 0.6316 (0.1710, 1.0921) | 4.59 | 34.6 |
| Sleep period time (min) | Included | 2 | -1.0499 (-1.6159, -0.4840) | 0.06 | 0 | 0.3381 |  |
| Excluded | 1 | -1.7019 (-2.9100, -0.4938) |  |  |
| Stage shift per hour | Included | 2 | 0.3533 (-0.1774, 0.8841) | 0.33 | 0 | 0.8404 |  |
| Excluded | 1 | 0.0059 (-1.0255, 1.0373) |  |  |
| Time in bed (min) | Included | 2 | -0.8555 (-1.4790, -0.2320) | 0.01 | 0 | 0.8404 |  |
| Excluded | 2 | -0.7647 (-1.3912, -0.1382) | 2.72 | 63.2 |
| Total sleep time (min) | Included | 2 | -1.1004 (-2.0046, -0.1962) | 0.04 | 0 | 0.2745 |  |
| Excluded | 4 | -0.4800 (-1.1283, 0.1682) | 9.43 | 68.2 |
| Wake after sleep onset (min) | Included | 2 | 0.1653 (-0.6163, 0.9469) | 0.03 | 0 | 0.9614 |  |
| Excluded | 3 | 0.1399 (-0.5262, 0.8060) | 5.99 | 66.6 |

Abbreviations: CI, confidence interval; k, the number of studies; NA, not available; REM, rapid eye movement.

## **Table S15. Statistical results of the subgroup analyses(Inclusion of Intellectual disability) - Actigraphy + Polysomnography**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sleep parameters | Subgroup | k | Meta-analysis | Heterogeneity | | p values | NA reason |
| Hedges' g (95% CI) | Q value | *I2* (%) |
| Sleep efficiency (%) | Included | 3 | -0.8040 (-1.2936, -0.3144) | 2.81 | 28.7 | 0.27 |  |
| Excluded | 7 | -0.4692 (-0.8072, -0.1312) | 13.22 | 54.6 |
| Sleep latency (min) | Included | 2 | 0.504947 (-0.22, 1.2343) | 0.03 | 0 | 0.7724 |  |
| Excluded | 6 | 0.6271 (0.2327, 1.0215) | 13.64 | 63.3 |
| Time in bed (min) | Included | 2 | -0.8568 (-1.4092, -0.3044) | 0.01 | 0 | 0.2816 |  |
| Excluded | 3 | -0.4788 (-0.8891, -0.0685) | 4.49 | 55.5 |
| Total sleep time (min) | Included | 3 | -1.2435 (-1.6061, -0.8810) | 0.51 | 0 | **<0.0005** |  |
| Excluded | 7 | -0.3907 (-0.6441, -0.1374) | 12.21 | 50.9 |

Abbreviations: CI, confidence interval; k, the number of studies; NA, not available.

## **Table S16. Statistical results of the subgroup analyses(Inclusion of Intellectual disability) - Subjective measurements**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sleep parameters | Subgroup | k | Meta-analysis | Heterogeneity | | p values | NA reason |
| Hedges' g (95% CI) | Q value | *I2* (%) |
| Daytime sleepiness | Included | 2 | 0.6319 (0.2505, 1.0133) | 4.12 | 75.7 | 0.3363 |  |
| Excluded | 5 | 0.4000 (0.1260, 0.6794) | 5.49 | 27.2 |
| Parasomnias | Included | 1 | 0.1782 (-0.7348, 1.0911) |  |  | 0.7056 |  |
| Excluded | 4 | 0.3808 (-0.1399, 0.9015) | 14.47 | 79.3 |
| Sleep disordered breathing | Included | 2 | 0.4525 (-0.4000, 1.3050) | 14.34 | 93 | 0.4487 |  |
| Excluded | 4 | 0.0377 (-0.6141, 0.6895) | 21.39 | 86 |
| Sleep latency | Included | 2 | 1.5322 (1.2610, 1.8033) | 0.18 | 0 | **<0.005** |  |
| Excluded | 3 | 0.7526 (0.3609, 1.1443) | 1.14 | 0 |
| Bedtime resistance |  |  |  |  |  |  | All individual studies excluded ID patients |
| Disorders in initiating and maintaining sleep | Included | 1 | 0.4058 (0.1002, 0.7114)) |  |  | **<0.001** |  |
| Excluded | 2 | 1.0733 (0.8345, 1.3121) | 0.62 | 0 |
| Night waking |  |  |  |  |  |  | All individual studies excluded ID patients |
| Sleep anxiety |  |  |  |  |  |  | All individual studies excluded ID patients |
| Sleep duration | Included | 1 | -0.7545 (-3.7531, 2.2441) |  |  | 0.4473 |  |
| Excluded | 2 | 0.6898 (-1.5203, 2.8999) | 11 | 90.9 |
| Sleep hyperhidrosis | Included | 1 | 0.4689 (0.0346, 0.9033) |  |  | 0.9099 |  |
| Excluded | 2 | 0.5000 (0.1820, 0.8179) | 1.84 | 45.6 |
| Sleep-wake transition disorders | Included | 1 | -0.0240 (-0.4139, 0.3659) |  |  | **<0.001** |  |
| Excluded | 2 | 0.8001 (0.5076, 1.0926) | 1.53 | 34.5 |
| Total sleep problem | Included | 3 | 0.8074 (0.3658, 1.2491) | 11.87 | 83.2 | 0.66 |  |
| Excluded | 4 | 0.9506 (0.4902, 1.4109) | 7.4 | 59.5 |

Abbreviations: CI, confidence interval; ID, intellectual disability; NA, not available; k, the number of studies.

# **eAppendix 12. Statistical results of the subgroup analyses - Questionnaires for sleep (Subjective measurement)**

**Table S17. Statistical results of the subgroup analyses - Questionnaires for sleep (Subjective measurement)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sleep parameters | Subgroup | k | Meta-analysis | Heterogeneity | | p values | NA reason |
| Hedges' g (95% CI) | Q value | *I2* (%) |
| Daytime sleepiness | CSHQ | 3 | 0.2188 (-0.0740, 0.5117) | 2.26 | 11.3 | **<0.05** |  |
| SDSC | 3 | 0.4397 (0.2575, 0.6219) | 1.69 | 0 |
| PSQ | 1 | 0.9084 (0.5256, 1.2912) |  |  |
| Parasomnias | CSHQ | 2 | 0.5918 (-0.2075, 1.3911) | 2.13 | 53.2 | 0.4379 |  |
| SDSC | 3 | 0.2269 (-0.2328, 0.6865) | 10.82 | 81.5 |
| Sleep disordered breathing | CSHQ | 2 | 0.3857 (-0.4865, 1.2578) | 2.29 | 56.3 | 0.1421 |  |
| SDSC | 3 | -0.1466 (-0.6934, 0.4003) | 17.4 | 88.5 |
| PSQ | 1 | 0.9336 (-0.0364, 1.9036) |  |  |
| Sleep latency | Sleep diary | 1 | 0.7928 (0.2267, 1.3588) |  |  | **<0.05** |  |
| CSHQ | 2 | 0.6980 (0.0620, 1.3340) | 1.08 | 7.3 |
| PSQ | 1 | 1.6006 (1.1145, 2.0867) |  |  |
| Sleep log assessment | 1 | 1.4831 (1.0512, 1.9149) |  |  |
| Bedtime resistance |  |  |  |  |  |  | All individual studies used CSHQ |
| Disorders in initiating and maintaining sleep |  |  |  |  |  |  | All individual studies used SDSC |
| Night waking |  |  |  |  |  |  | All individual studies used CSHQ |
| Sleep anxiety |  |  |  |  |  |  | All individual studies used CSHQ |
| Sleep duration | CSHQ | 2 | 0.6898 (-1.5203, 2.8999) | 11 | 90.9 | 0.4473 |  |
| Sleep log assessment | 1 | -0.7545 (-3.7531, 2.2441) |  |  |
| Sleep hyperhidrosis |  |  |  |  |  |  | All individual studies used SDSC |
| Sleep-wake transition disorders |  |  |  |  |  |  | All individual studies used SDSC |
| Total sleep problem | CSHQ | 3 | 0.6834 (0.2531, 1.1137) | 5.95 | 66.4 | 0.2664 |  |
| SDSC | 3 | 0.8383 (0.4852, 1.1914) | 4.86 | 58.8 |
| PSQ | 1 | 1.3290 (0.6765, 1.9814) |  |  |

Abbreviations: CI, confidence interval; CSHQ, Children's Sleep Habits Questionnaire; k, the number of studies; NA, not available; PSQ, Pediatric Sleep questionnaire; SDSC, Sleep Disturbance Scale for Children.

# **eAppendix 13. Funnel plot, p-curve analysis plot, and influence analysis plot**

## **13.1. Actigraphy**

### **Figure S2. Funnel plot and influence analysis plot for Sleep efficiency (%)**

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### **Figure S3. Funnel plot for Sleep latency(min)**

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| --- | --- |
|  | - |

### **Figure S4. Funnel plot and influence analysis plot for Total sleep time (min)**

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| --- | --- |
|  |  |

### **Figure S5. Funnel plot for Wake after sleep onset (min)**

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| --- | --- |
|  | - |

## **13.2. Polysomnography**

### **Figure S6. Funnel plot and influence analysis plot for Number of awakenings per hour**

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| --- | --- |
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### **Figure S7. Funnel plot for REM density (no./h REM sleep)**

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### **Figure S8. Funnel plot and influence analysis plot for REM latency (min)**

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| --- | --- |
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### **Figure S9. Funnel plot and influence analysis plot for REM sleep (%)**

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| --- | --- |
|  |  |

### **Figure S10. Funnel plot and influence analysis plot for S1 (%)**

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| --- | --- |
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### **Figure S11. Funnel plot and influence analysis plot for S2 (%)**

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### **Figure S12. Funnel plot and influence analysis plot for Slow wave sleep (%)**

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| --- | --- |
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### **Figure S13. Funnel plot and influence analysis plot for Sleep efficiency (%)**

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| --- | --- |
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### **Figure S14. Funnel plot and influence analysis plot for Sleep latency (min)**

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| --- | --- |
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### **Figure S15. Funnel plot, p-curve plot, and influence analysis plot for Sleep period time (min)**

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| **Chart, line chart  Description automatically generated** |  |

### **Figure S16. Funnel plot and influence analysis plot for Stage shift per hour**

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### **Figure S17. Funnel plot and influence analysis plot for Time in bed (min)**

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### **Figure S18. Funnel plot, p-curve plot, and influence analysis plot for Total sleep time (min)**

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| --- | --- |
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| Chart, line chart  Description automatically generated |  |

### **Figure S19. Funnel plot and influence analysis plot for Wake after sleep onset (min)**

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## **13.3. Actigraphy + Polysomnography**

### **Figure S20. Funnel plot, p-curve plot, and influence analysis plot for Sleep efficiency**

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| Chart, line chart  Description automatically generated |  |

### **Figure S21. Funnel plot and influence analysis plot for Sleep latency (min)**

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### **Figure S22. Funnel plot and influence analysis plot for Time in bed (min)**

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### **Figure S23. Funnel plot, p-curve plot, and influence analysis plot for Total sleep time (min)**

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| --- | --- |
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| Chart, line chart  Description automatically generated |  |

## **13.4. Subjective measurement**

### **Figure S24. Funnel plot, and p-curve plot, and influence analysis plot for Daytime sleepiness**

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### **Figure S25. Funnel plot and influence analysis plot for Parasomnias**

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### **Figure S26. Funnel plot and influence analysis plot for Sleep disordered breathing**

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### **Figure S27. Funnel plot, p-curve plot, and influence analysis plot for Sleep latency**

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| --- | --- |
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| Chart, line chart  Description automatically generated |  |

### **Figure S28. Funnel plot for Bedtime resistance**

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### **Figure S29. Funnel plot, and p-curve plot, and influence analysis plot for Disorders in initiating and maintaining sleep**

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### **Figure S30. Funnel plot for Night waking**

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### **Figure S31. Funnel plot for Sleep anxiety**

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### **Figure S32. Funnel plot and influence analysis plot for Sleep duration**

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| --- | --- |
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### **Figure S33. Funnel plot, and p-curve plot, and influence analysis plot for Sleep hyperhidrosis**

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| Chart, line chart  Description automatically generated |  |

### **Figure S34. Funnel plot and influence analysis plot for Sleep-wake transition disorders**

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| --- | --- |
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### **Figure S35. Funnel plot, and p-curve plot, and influence analysis plot for Total sleep problem**

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| --- | --- |
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| Chart, line chart  Description automatically generated |  |